Appendix L

City of Lincoln
Groundwater Management Plan

Groundwater Management Plan

Saracino • Kirby • Snow
A Schlumberger Company

Prepared for the City of Lincoln

November 2003

CITY OF LINCOLN

GROUNDWATER MANAGEMENT PLAN

Saracino·Kirby·Snow
A Schlumberger Company

November 2003

This Groundwater Management Plan was prepared for the City of Lincoln Department of Public Works. It was developed and adopted through the efforts of the staff and elected officials at the City of Lincoln, water agencies that provide surface water to the City, a Groundwater Management Plan Advisory Committee, consultants and members of the Lincoln community.

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1

INTRODUCTION

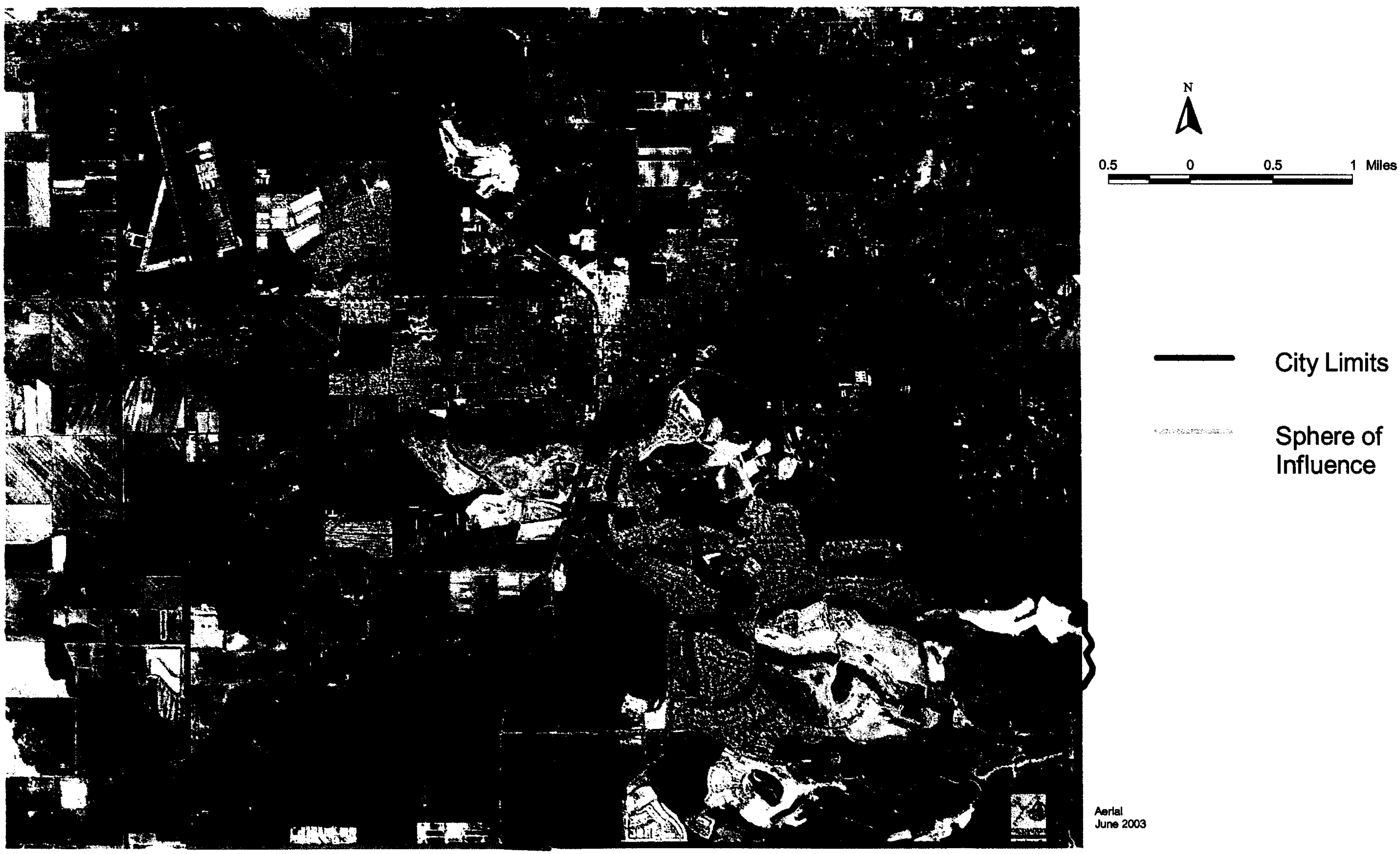
The City of Lincoln (City) is located in western Placer County and has a population of approximately 22,900. The City limits and Sphere of Influence (SOI) are shown on a 2003 aerial photograph in Figure 1. The City relies primarily on surface water provided by the Placer County Water Agency (PCWA) to meet its treated water supply needs. To provide backup and emergency potable water supplies, the City owns and operates four municipal water supply wells. Water from these wells also provides a supply when surface water supplies are unable to meet daily peak demands[1].

The Groundwater Management Act, also known as Assembly Bill 3030 (AB 3030), encourages local agencies to manage groundwater resources within their jurisdiction. The City provides groundwater within its service area and is therefore considered a local agency authorized to adopt an AB 3030 Groundwater Management Plan (GMP). The Plan area coincides with the City's 39 square mile (SOI).

"The Legislature finds and declares that groundwater is a valuable natural resource in California, and should be managed to insure both its safe production and its quality." California Water Code

Recognizing the importance of effective groundwater management to protect the City's water supply and the health and safety of its customers, the Lincoln City Council passed Resolution No. 98-103 on September 22, 1998, formalizing the City's intention to draft a Groundwater Management Plan pursuant to the Groundwater Management Act. A second resolution No. 2002-43 was passed at a properly noticed public hearing on March 26, 2002, extending the date for Plan completion. A copy of Resolution 2002-43 is included in Appendix A.

[1] Use of municipal wells for backup, emergency and peak needs is more fully described in Section 3.



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Lincoln City Limits and Sphere of Influence

City of Lincoln
Groundwater Management Plan

Figure 1

Date: October 2003

Prepared By: BCW

The City Director of Public Works authorized the development of this Plan to guide in the effective administration of the groundwater resources within the City boundaries.

Legal Authority Under AB 3030

The California State Legislature passed the Groundwater Management Act (Act) during the 1992 legislative session and the Act became effective on January 1, 1993. The Act, as codified in California Water Code Sections 10750 *et seq.*, declares that groundwater is a valuable resource that should be carefully managed to ensure its safe production and quality. The Act also encourages local agencies to work cooperatively to manage groundwater resources within their jurisdiction.

The Act applies to all groundwater basins identified in the California Department of Water Resources (DWR) Bulletin 118 (DWR, 1980), except for those basins already subject to specialized groundwater management. The City overlies a portion of the North American Subbasin of the Greater Sacramento Valley Groundwater Basin, as defined by DWR in Bulletin 118 (see Section 2). This basin is not adjudicated or otherwise managed pursuant to law.

The Director of Public Works/City Engineer is responsible for directing the necessary and appropriate actions to implement the City's Groundwater Management Plan.

Groundwater Management Plan Components

Section 10753.7 of the Act identifies 12 components that may be included in a Groundwater Management Plan. An agency preparing a plan may select among the components that are applicable to the particular hydrogeologic setting and needs of the agency. The City of Lincoln GMP addresses the following components in Section 5 of this report:

1. Control of saline water intrusion

2. Identification and management of wellhead protection areas and recharge areas

3. Regulation of the migration of contaminated groundwater

4. The administration of a well abandonment and well destruction program

5. Mitigation of conditions of overdraft

6. Replenishment of groundwater extracted by water producers
7. Monitoring of groundwater levels, quality and storage
8. Facilitating conjunctive use operations
9. Identification of well construction policies
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects
11. The development and maintenance of relationships with state, federal and local regulatory agencies
12. The review of land use plans and coordination with land use planning agencies to assess activities that create a reasonable risk of groundwater contamination

Integrated Water Management Planning

The City of Lincoln has taken an integrated approach to its water management planning that encompasses numerous elements including water supply reliability, water recycling, water conservation, water quality protection and improvement, storm water management, wetland protection, and protection of the environment and habitat. This Groundwater Management Plan is an important component of the City's Integrated Water Management Planning efforts.

City of Lincoln Strategic Water Plan

The 2002 City of Lincoln's Strategic Water Plan addresses the following elements:

- Develop emergency water backup plan
- Improve storage and transmission
- Utilize groundwater for conjunctive use
- Develop water reclamation and conservation
- Provide safe and affordable drinking water

Urban Water Management Plan

The City adopted its first Urban Water Management Plan in December 2002. The plan was developed in accordance with provisions in the California Water Code and contains sections that address topics in the following outline.

1. Plan Development
2. Service Area Description
3. Water Supply
4. Water Quality
5. Demand
6. Water Recycling
7. Supply and Demand Comparison
8. Water Shortage Contingency
9. Water Conservation

> ***California Water Code***
> ***"Every urban water supplier shall make every effort to assure the reliability of its water supply during normal, dry and multiple dry years"***

Since the plan identified groundwater as a source of supply it was required to include a section that describes the groundwater basin, estimates of the amount of groundwater in storage, and determines the sufficiency of groundwater to meet expected demands.

Wastewater Reclamation Plan

A City of Lincoln Wastewater Reclamation Study was initiated in 2001 and completed in February 2003. The purpose of the study is to determine the potential for reclaiming treated wastewater from the new Waste Water Treatment and Reclamation Facility (WWTRF). According to a final draft, the objectives of the study are to:

1. Identify potential reclamation areas near the plant

2. Review water supplies available in the area
3. Analyze applicable wastewater recycling regulations and summarize their impact on wastewater treatment facilities
4. Evaluate the market for wastewater reclaiming opportunities
5. Identify and prioritize the most likely projects for wastewater reclamation

Once the WWTRF is operational, the treated effluent will be suitable for the following uses:

1. Irrigation of food crops
2. Irrigation of parks and playgrounds, with use of appropriate warning signs indicating the water is unsafe for drinking
3. Irrigation of schoolyards, with use of appropriate warning signs indicating the water is unsafe for drinking
4. Irrigation of residential landscaping and golf courses, with use of appropriate warning signs indicating the water is unsafe for drinking
5. Water supply source for recreational impoundments, with use of appropriate perimeter signs

The City has recently received a $750,000 grant from the State Water Resources Control Board, Office of Water Recycling. This grant money is to extend a 24-inch reclamation pipeline approximately 3,000 feet for effluent reuse on approximately 600 acres of land. The City currently reuses wastewater effluent to irrigate approximately 380 acres of land for hay production.

City Goals and Objectives

This Groundwater Management Plan (GMP) provides a framework for the City to effectively manage and protect its groundwater resources. This framework describes the series of steps necessary to manage the basin, beginning with collecting the necessary data and developing a stakeholder participation

> ***The City's groundwater management practices shall not, in and of themselves, adversely impact adjacent areas.***

program. The City's groundwater management practices and conjunctive use program will be based on the Basin Management Objectives (BMOs) established for the Lincoln SOI, and shall not, in and of themselves, adversely impact adjacent areas. BMOs are discussed further in Section 4.

Recommendations for completing these objectives are contained in a subsequent section of this GMP.

Coordination with Other Agencies in the Basin

Plan to Involve Entities in the Basin

Recognizing that other entities' service areas or boundaries overly the groundwater basin utilized by the City of Lincoln, a plan was developed to incorporate their input into development and implementation of the City's Groundwater Management Plan. The plan involves coordination with the Placer County Board of Supervisors and Public Works Department, Lincoln Planning Department, the Regional Water Authority[2] and the two surface water purveyors – Placer County Water Agency and the Nevada Irrigation District. This coordination has and will continue to take place through direct meetings with staff from these entities and through the City's Groundwater Management Plan Advisory Committee.

A map depicting a portion of the Sacramento Valley North American Groundwater subbasin and water agency boundaries is presented in Figure 2.

Placer County Water Agency

The Placer County Water Agency (PCWA) was created in 1957 and encompasses over 1,400 square miles, the entire County of Placer. PCWA is considered a local agency for purposes of groundwater management. PCWA advises city and county officials on activities and water issues with the objective of insuring that Placer County's water resources will be available for present and future beneficial uses of the County. PCWA has expressed their interest in matching water resource supplies to Placer County land usage. The majority of the City of Lincoln is within the boundaries of PCWA.

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[2] RWA members are listed on pages 1-15 and 1-16.

West Placer Groundwater Management Plan

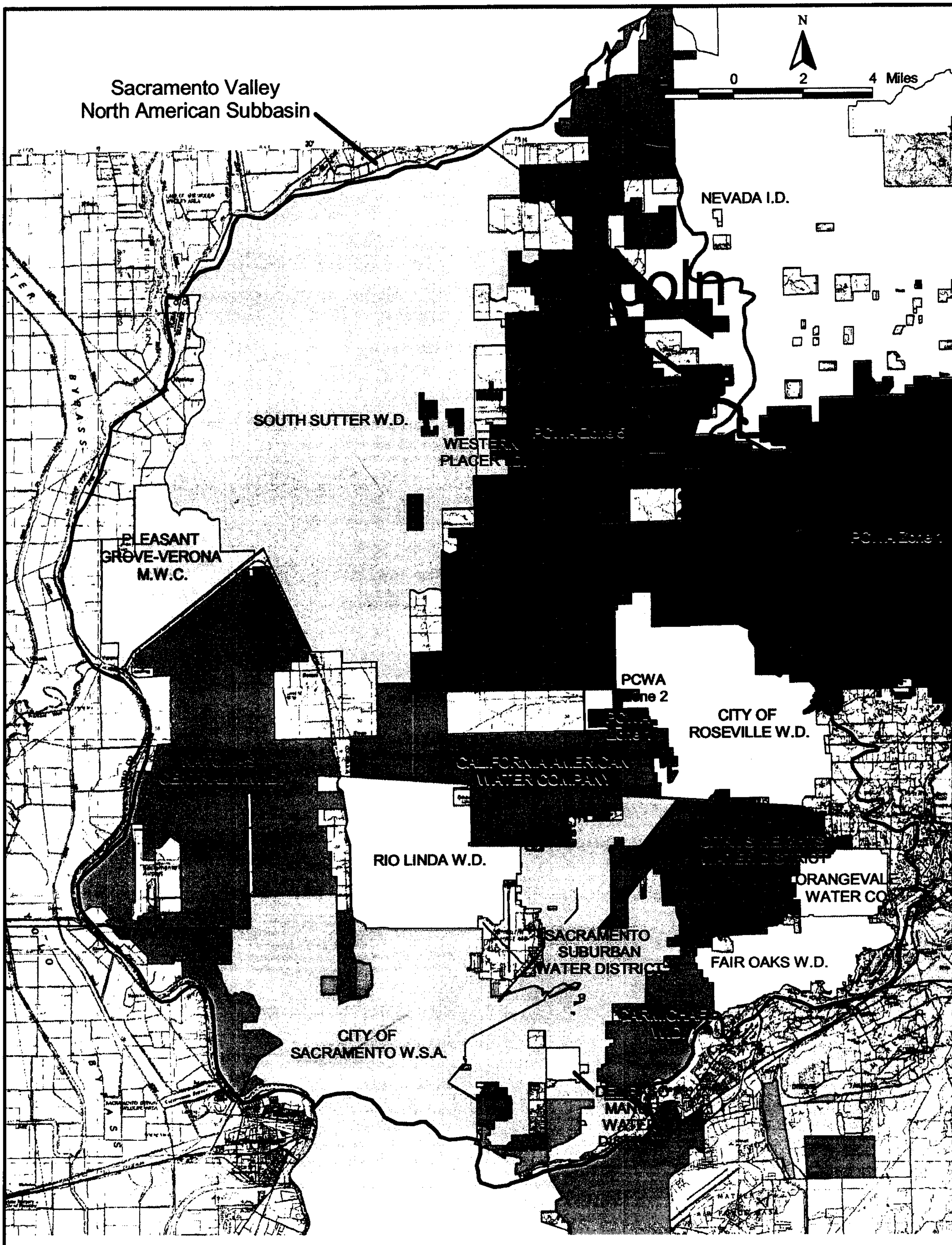
Placer County Water Agency adopted the West Placer Groundwater Management Plan in 1998. According to the plan, the primary objective is to facilitate studies and activities to restore and maintain groundwater quality and quantity in the basin. The plan consists of the following elements:

1. Monitoring of groundwater levels and groundwater quality
2. Identifying groundwater recharge opportunities, with particular emphasis on the area adjacent to the Placer/Sacramento county line
3. Identifying conjunctive use opportunities for non-residential uses in the area north of Pleasant Grove Creek
4. An evaluation of the safe yield
5. Maximizing groundwater management coordination with all jurisdictions, landowners, and the general public within west Placer County, with those jurisdictions in north Sacramento County portions of the basin, and with the appropriate State and Federal agencies

PCWA is currently in the process of updating its GMP to meet new requirements added to the California Water Code since adoption of their plan in 1998.

> ***"It is the intent of the Legislature to encourage local agencies to work cooperatively to manage groundwater resources within their jurisdictions."***
> ***California Water Code***

The West Placer Groundwater Management Plan covers an area smaller than the boundaries of the Placer County Water Agency. The plan area includes "the cities of Roseville and Rocklin and the unincorporated portion of west Placer County that is bounded by the following: on the east by the Nevada Irrigation District and the western boundary of the City of Lincoln; on the north by the Bear River; on the west by the South Sutter Water District boundary and the Placer County/Sutter County line; and on the south by the Placer County/Sacramento County line." The City of Lincoln is included in the Placer County Water Agency boundaries but is not included in the boundaries of the West Placer Groundwater Management Plan. Preparation of the City of Lincoln GMP is being coordinated with Placer County Water Agency.



Saracino·Kirby·Snow A Schlumberger Company	North American Groundwater Subbasin and Overlying Water Suppliers **City of Lincoln** **Groundwater Management Plan**	Figure 2 Date: October 2003 Prepared By: BCW

The following description of PCWA water supplies is excerpted from its 2000 Urban Water Management Plan.

> "The Water Systems Division's current main source of water is from the Yuba and Bear Rivers. This supply comes from lake Spalding and is purchased from Pacific Gas and Electric Company. The American river provides a second source from appropriated water rights developed through construction of the Middle Fork Project. A third source is from the United States Bureau of Reclamation Central Valley Project (CVP). PCWA's fourth source is from wells."

Nevada Irrigation District

The Nevada Irrigation District (NID) utilizes surface water for its supply of irrigation and urban water demands. The supply consists of runoff from the watershed, carryover storage in surface reservoirs, contract purchases, and recycled water. Portions of the City of Lincoln are included in NID's boundaries. The following description of NIDs water supplies is excerpted from its 2001 Urban Water Management Plan.

Watershed Runoff

> "The amount of runoff from the NID watershed and the manner in which it is used depends a great deal on the amount of water contained in the snow pack and the rate that the snow pack melts. Ideally, melting snow provides runoff lasting into June or July. The system of storage reservoirs and conduits used to transport water to NID's service area boundary are referred to as the Upper Division. The Upper Division is operated in conjunction with the PG&E under the terms of a joint agreement. In periods of normal precipitation, ample runoff is available for power production. Conversely, power production is sacrificed to avoid supply deficiencies during dry years. Maximum capacity of key conduits in the Upper Division limits the amount of runoff that can be used for consumptive purposes."

Carryover Storage

> "NID has ten main storage reservoirs totaling a maximum of 250,280 acre-feet. Carryover storage is the amount of water left in

these reservoirs at the end of the normal irrigation season, usually at the end of September. Experience has shown that carryover storage should be held at a level not less than 70,000 AF. This figure includes a total 39,675 AF of minimum pool requirements for environmental needs and dead storage (includes siltation estimates), which cannot be counted upon as a supply."

Contract Purchases

"Contract water purchases are available each year through a 1963 agreement with PG&E. In years of at least normal precipitation, the maximum amount available is 59,361 AF. This amount reduces in dry years to a maximum of 23,591 AF. It should be noted that the contract expires 2013. A renegotiated contract has the potential of affecting NID's over all water supply. However, staff does not foresee any major changes over present operations once negotiations have been concluded. NID's Board of Directors has established a reserve fund to meet the anticipated expense of relicensing the multi-unit hydroelectric facility through the Federal Energy Regulatory Commission."

Recycled Water

"This supply is made up of effluent from municipal wastewater treatment plants that is captured and mixed with surface waters. This occurs below four municipal wastewater treatment plants: Grass Valley, Nevada City, Auburn, and Placer County at Joeger Road. This recycled wastewater is not used as a raw water supply for NID's treated water plants with the exception of the small town of Smartville where it is mixed with a large volume of surface water and transported through miles of natural drainage courses and earthen canals. The capture of this water augments NID's overall surface supply and is included as a source of supply."

Placer County Board of Supervisors

According to their web page, Placer County Division of Environmental Health provides services as noted below in the excerpt below:

"At a community-wide level, we provide preventive and corrective public health programs, and monitor the development of land uses to assure long-range and short-term community health. Specific services rendered include health inspections of retail food facilities, public swimming pools & spas; reviewing and inspecting land use applications filed with the County for a wide range of development; monitoring the proper use, storage, and disposal of hazardous materials; inspection of underground storage tanks to prevent leakages; and the permitting of well drilling and septic systems to assure the integrity of the County's groundwater resources."

Regional Water Authority

The Regional Water Authority (RWA) is a joint powers authority that serves and represents the interests of 21 water providers in the greater Sacramento, Placer and El Dorado County region. RWA's primary mission is to help its members protect and enhance the reliability, availability, affordability and quality of water resources.

Formed in 2001 after two years of facilitated workshops with more than 60 water industry leaders, RWA consolidated several regional associations to promote collaboration and provide a unified voice on Northern California water issues.

RWA has launched significant programs and services on a regional scale, including:

- A water efficiency program designed to help local purveyors implement best management practices on a regional basis
- Implementation of the American River Basin Regional Conjunctive Use Program, utilizing a $22 million grant from the California Department of Water Resources

The City of Lincoln is a member of RWA. Members of RWA include:

Member Agencies
California-American Water Company
Carmichael Water District
Citrus Heights Water District
Del Paso Manor Water District
El Dorado Irrigation District
Fair Oaks Water District
Folsom, City of
Fruitridge Vista Water Company
Lincoln, City of
Orange Vale Water Company

Placer County Water Agency
Rancho Murieta CSD
Roseville, City of
Rio Linda/Elverta CWD
Sacramento, City of
Sacramento Suburban Water District
San Juan Water District
Southern California Water Co.

RWA Associates
El Dorado County Water Agency
Sacramento Municipal Utility District
Sacramento Regional County

Sanitation District

Land Use and Zoning Agencies

The Placer County Planning Department is the lead entity involved with planning and zoning. According to the County's web site the Planning Department performs the following tasks:

- "Provides information on land development, then reviews and makes recommendations on land development applications
- Helps the Board of Supervisors and Planning Commission plan for growth by providing professional and technical expertise
- Leads the preparation of community plans as well as county-wide plans which set the guidelines for future growth. Investigates complaints of code violations"

"The Planning Commission is the principal advisory body to the Board of Supervisors on planning and land use matters, and regulations related to planning, land use and long range plans for development. There are seven Planning Commissioners appointed by the Board of Supervisors. Five commissioners represent the five supervisorial districts and two at-large commissioners, one representing the county of the Sierra crest, and one representing the county west of the crest." (http://www.placer.ca.gov/planning/planning.htm)

Public Participation

In order to provide a mechanism for stakeholders and interested parties to have input into the development and implementation of the City's Groundwater Management

Plan, the City organized an Advisory Committee. The Committee currently includes the following representatives:

- Lincoln City Council
- City of Lincoln General Manager
- Lincoln Public Works Department
- Lincoln Planning Department
- Placer County Water Agency
- Placer County Board of Supervisors
- Placer County Planning Department
- Nevada Irrigation District
- Regional Water Authority
- Lincoln Chamber of Commerce
- Rural Landowners
- Building Industry
- Gladding McBean Quarry
- Placer County Agricultural Commissioner
- Ranching/farming representative

Agendas and meeting notes from the four Advisory Committee meetings are included in Appendix E.

This GMP has been updated to address comments and concerns received from the members of the Advisory Committee and the public during the Advisory Committee meetings.

2

Physical Setting

Climate

The climate in Lincoln is characterized as the Mediterranean type. Average monthly temperatures range from above freezing in winter to the upper 90's in the summer. Daily extremes range from below freezing in the winter to over 100 degrees Fahrenheit in the summer. Storms generally occur between November and April. Average annual precipitation for the Lincoln area is approximately 22 inches (WRCC, 2003).

A summary of climate data is presented in Table 1. Temperature and precipitation data are from the Western Regional Climate Center in Rocklin (WRCC, 2003). Reference evapotranspiration (ETo) data are from the Department of Water Resources' Model Landscape Ordinance (DWR, 1992). Evapotranspiration is the sum of surface evaporation and transpiration through vegetation. Reference evapotranspiration is a term used to describe the evapotranspiration rate from a known crop, such as grass or alfalfa, and is useful in estimating landscape irrigation requirements. Monthly ETo minus monthly precipitation represents an estimate of the amount of irrigation needed.

Table 1: Summary of Climate Data

Month	Temperature (^oF) Avg. Max	Temperature (^oF) Avg. Min	Precipitation (Inches)	ETo (Inches)
JAN	52.9	33.3	4.94	1.2
FEB	59	36.5	3.29	1.6
MAR	63.5	38.7	2.98	2.8
APR	70.9	42	1.82	4.7
MAY	80.2	47.8	0.51	6.1
JUN	89.5	53.5	0.21	7.4
JUL	97.2	57.6	0.07	8.4
AUG	95.8	56.6	0.06	7.3
SEP	90.2	52.7	0.26	5.4
OCT	78.3	45.3	1.36	3.7
NOV	64.2	38.8	3.16	1.9
DEC	53.7	34.5	3.82	1.2
Average			22.48	51.7

Surface Water

Water courses and drainages in the Lincoln area flow from the foothills east of Lincoln westerly toward the Sacramento River. The Lincoln GMP area coincides with the City's Sphere of Influence (SOI) and extends across several local watersheds. Markham Ravine and Auburn Ravine are present in the northern portion of the SOI. The other surface water drainages include Ingram Slough, the Orchard Creek watershed, and a minor portion of the Pleasant Grove Creek watershed, which is located at the south end of the City SOI. Presently, community residential and commercial development exists within the Auburn Ravine and Ingram Slough watersheds. The newly annexed land developments to the south are within the remaining watersheds.

Surface water within the City SOI is dominated by the seasonal rainfall runoff flows from the Markham Ravine and Auburn Ravine watersheds. Both ravines are part of the Coon Creek Basin. The seasonal influence of creeks and drainages on groundwater recharge within the Lincoln GMP area is described in following sections.

The area's topography, vegetative cover, soil types, and areas with impermeable surfaces influence stormwater drainage within the SOI. Except for the relatively flat developed area of the City of Lincoln, the topography is characterized by gently rolling grasslands. Ground surface elevation in the Lincoln SOI increases to the east, to approximately 600 feet above sea level.

PCWA Untreated Surface Water

Lincoln is located in the Placer County Water Agency (PCWA) Zone 1 service area. PCWA obtains water for Zone 1 from either PG&E's Wise/South Canal or PCWA's Boardman Canal. Sources for this water are the Bear and Yuba Rivers. Water from the American River may also be utilized to service Zone 1 (Brown and Caldwell, 2000). Raw surface water is transported to the PCWA Sunset and Foothill Treatment Plants. PCWA also delivers untreated surface water via PCWA's Capertown Canal system to raw water customers within the City of Lincoln. Some developments within the City have contracts to raw surface water and this water is utilized for irrigation when available.

PCWA Treated Surface Water

The City of Lincoln purchases treated surface water from the Sunset and Foothill Treatment Plants through a long-term contract with the PCWA and distributes the water to Lincoln businesses and residents through the City's Zone A distribution system.

Groundwater

The Lincoln service area is located in the northeastern part of California's Central Valley, bordering the foothills of the Sierra Nevada Mountain Range. The Central Valley is referred to as the Great Valley geomorphic province – a large structural depression underlain and bounded on the east by the gently westward-dipping Sierra Nevada and on the west by the complexly folded-faulted Coast Ranges (DWR, 1995). The surrounding mountains are generally composed of non-water bearing rocks, whereas the Great Valley is filled with water-bearing sediments accumulating from the surrounding mountains. Most of the surface water within the Great Valley is derived from rivers and streams descending from the surrounding mountains and uplands. The Sacramento Valley comprises the northern one-third of the Great Valley.

The large accumulation of sediments within the Great Valley were originally deposited in a marine environment from the Cretaceous to the Eocene (the latter period spanning 60.5 to 38.6 million years ago), and as late as the Pliocene (6.7 to 3.4 million years ago) in some places; these sediments compose the lower layers of the Valley and contain predominantly brackish or saline water. From the mid-Eocene into the Miocene (the latter spanning 29.3 to 6.7 million years ago) volcanic eruptions in the Sierra Nevada deposited pyroclastic rocks, lava flows, and mudflows down the western slopes; these volcanic rocks were eroded and deposited in marine and continental environments within the Great Valley. The Sacramento Valley was in its current configuration by the Pliocene and fluvial (river and stream) sediment deposition dominated from that time forward. The Miocene-Pliocene and younger volcanogenic and fluvial sediments, deposited in a continental environment, dominate the Sacramento Valley freshwater aquifer system. The base of freshwater deepens westward from about 400 feet below sea level near the Sierra Nevada foothills to over 1200 feet at the axis of the valley (approximately the location of the Sacramento River).

The Lincoln Sphere of Influence is located in the eastern central part of the Sacramento Valley Groundwater Basin, within the North American Subbasin as defined by DWR (2002a). These areas are described in more detail below.

Sacramento Valley Groundwater Basin

The Sacramento Valley Groundwater Basin is an important resource, estimated by DWR to contain approximately 114 million acre-feet of water. Several fresh water-bearing zones (aquifers) are present beneath the Basin's 15,500 square mile surface area, ranging in depth from near surface to 3,000 feet below surface.

North American Groundwater Subbasin

The North American Groundwater Subbasin (Figure 2) lies within Sutter, Placer, and Sacramento Counties and is delimited by the Bear River on the north, the Feather River and the Sacramento River on the west, the American River on the south, and the Sierra Nevada foothills on the east. The eastern boundary represents the approximate edge of the alluvial basin, where little or no groundwater flows into or out of the groundwater basin from the Sierra Nevada basement rock; this boundary passes about two miles east of the town of Lincoln (DWR, 2002a). The other boundaries – all major perennial rivers – represent partial groundwater divides, where at shallow depths there is little groundwater flow from the aquifer system on one side of the river to the aquifer system on the other side; however, at greater depths there is groundwater flow across these boundaries. The eastern portion of the subbasin is characterized by low rolling dissected uplands. The western portion is a nearly flat flood basin for the Bear, Feather, Sacramento and American rivers, and several small east side tributaries. The general direction of drainage (land surface slope) is west-southwest at an average grade of about 0.4 percent. The approximate total storage of the North American Subbasin is 4.9 million acre-feet of water, assuming an aquifer thickness of 200 feet across the total 351,000 acres of the basin and a specific yield of 7% (DWR, 2002a).

Lincoln Sphere of Influence

Most of the Lincoln Sphere of Influence (see Figure 1) lies within the North American Groundwater Subbasin, although parts of the eastern section extend beyond the water-bearing sediments of the subbasin into the western reaches of the Sierra Nevada foothills. A number of groundwater studies have been performed in the Lincoln area. A fairly extensive aquifer mapping investigation of the Lincoln SOI, that incorporated geophysical surveys and drill hole and geologic analyses, was carried out by Spectrum-Gasch, Inc. (1999), to assess groundwater resources and identify development opportunities. Earlier, a groundwater investigation was performed in the vicinity of the Lincoln Airport by Boyle Engineering Corporation (1990) to assess the groundwater production capability in that area.

A comprehensive integrated ground-surface water model (IGSM) for the northern American River area, comprising western Placer and southern Sutter counties, was developed by Montgomery Watson (1995) and included a fairly extensive study of hydrogeology and hydrology of the region. This model has subsequently been used for a number of regional groundwater studies (DWR, 1995; Montgomery Watson, 1996). Localized hydrogeologic field investigations and groundwater modeling analysis have been conducted in the area just north of Lincoln by Teichert, Inc. and their consultant, Luhdorff & Scalmanini (LSCE, 1997), to evaluate the impacts of proposed aggregate mining in the area.

Hydrogeology

Groundwater aquifers can be confined (capped by an impervious layer) or unconfined (in direct communication with the surface, under atmospheric pressure conditions). A confined aquifer may be highly confined (no direct connection with overlying aquifer/surface) or semi-confined (partially connected to overlying aquifer/surface). The aquifers in the Lincoln SOI vary from unconfined to semi-confined conditions.

The fresh water bearing deposits of the North American Groundwater Subbasin are divided into two broad aquifer systems based on lithologic and hydrologic differences. The division between the two is inexact due to the lithologic heterogeneity of the subbasin coupled with the lack of comprehensive information about subsurface geology and groundwater conditions. The above-mentioned field investigations indicate that there is a significant amount of variability in these aquifer systems – their thickness, horizontal and vertical extent of individual geologic layers, presence of confining/semi-confining layers, and hydrologic properties. The hydrogeology of the two aquifer systems is briefly described below.

The two aquifer systems consist of a number of different geologic formations, classified by their age and how they were formed. In drill holes it is often difficult to distinguish between different geologic formations in the subsurface, although there are marker beds that are readily recognized.

Upper Unconfined / Semi-Confined Aquifer System

This aquifer system lies directly below the land surface and is composed of pre-Miocene alluvium deposits. It varies in thickness from as much as 300 feet in the western part of the Lincoln SOI to pinching out in the eastern part. The aquifer system contains generally thin sands and gravels that are laterally discontinuous, separated by low permeability clay and silt. Aquifer conditions appear to be unconfined based on the direct response of groundwater levels to imposed stresses. However, throughout much of the Lincoln area, except near creeks and ravines, a low permeability clay soil or "hardpan" layer exists near surface that likely restricts vertical flow and deep percolation into the aquifer. This horizon may act as an upper semi-confining layer to the aquifer in places.

Well production in the upper aquifer system is dependent on how much coarse grained aquifer material (sand or gravel) is intersected by the well, and has been reported as high as 1,800 gpm (Montgomery Watson, 1995). Aquifer pumping tests performed in one of the geologic formations of this aquifer system, the Riverbank Formation (see below for description), indicated a hydraulic conductivity of 5,600 gallons per day per square foot (gpd/ft^2) and a specific yield of 10% (LSCE, 1997).

However, hydraulic conductivity values of 75 to 750 gpd/ft^2 were assigned to the corresponding aquifer system in the calibrated groundwater model used in the same study, while values ranging from 100 to 150 gpd/ft^2 were used in the calibrated IGSM model for the Northern American River Service Area (Montgomery Watson, 1995).

From youngest to oldest, the three geologic units that comprise the upper aquifer system include Holocene alluvium, the Pleistocene Riverbank Formation, and the Pliocene-Pleistocene Laguna Formation.

ALLUVIUM

The youngest alluvium consists of unweathered gravel, sand and silt deposited by present-day creeks and drainages. These deposits are primarily located along the surface streams in the area. Their depositional thickness and areal coverage is not significant and they do not yield appreciable quantities of groundwater.

RIVERBANK FORMATION

The Riverbank Formation contains a heterogeneous mixture of silt, sand, gravel, and clay – exhibiting extreme grain size variability over short lateral and vertical distances (DWR, 1995). The formation often is differentiated into two members:

- Upper Member – an unconsolidated, dark brown to reddish-colored alluvium deposit composed of gravels, sands and silt with minor amounts of clay
- Lower Member – a semi-consolidated, red-colored alluvium deposit composed of gravels, sands and siltstone that represent remnants of dissected alluvial fans

The deposits are widespread throughout western Placer and northern Sacramento counties along the gently rolling foothills and often considered an important aggregate resource. Their thickness varies, with a maximum thickness of 50 to 75 feet. The formation is moderately permeable overall, with highly permeable coarse-grained zones. Where saturated, these deposits can yield appreciable quantities of groundwater.

LAGUNA FORMATION

This geologic unit is composed of a heterogeneous mixture of tan/brown interbedded alluvial sand, silt, and clay, with some gravel lenses – deposited by ancestral rivers and streams that drained the Sierra Nevada. The formation generally increases in thickness toward the west and has a maximum thickness of about 200 feet. In certain portions of Placer and Sacramento Counties, the Laguna Formation is similar in depth, thickness and composition to the overlying Riverbank Formation – but generally it is more fine-grained than overlying formations (DWR, 1995). Where this unit is saturated, appreciable quantities of groundwater can be produced, although most wells within the unit have low to moderate yields.

Lower Semi-Confined Aquifer System

This aquifer system occurs below the upper aquifer system, separated by a semi-confining layer, and is composed of Miocene/Pliocene clastic deposits of volcanic origin that vary in thickness from greater than 200 feet in the western part of the area to less than 10 feet in the eastern part. This aquifer also contains significant amounts of low permeability clay and silt, but the coarse zones, although laterally discontinuous, appear to be somewhat thicker than those of the upper aquifer system. Aquifer conditions appear to be at least partially confined based on the limited response of groundwater levels to imposed stresses at shallow depths. The semi-confining layer dividing the two aquifer systems consists of a clay layer and/or a hard, consolidated volcanic tuff-breccia layer; both have varying thickness and spatial extent. The base of the lower aquifer system is defined by the base of the fresh water-bearing zone or the top of the regional geologic basement complex of the Sierra Nevada foothills, the former in the western part of the Lincoln area and the latter in the eastern part.

The lower aquifer system is capable of large well yields – two wells near Coon Creek are reported to produce approximately 3,000 gpm each (DWR, 1995) – but well yield is dependent on the combined thickness of sand or gravel intersected by the well. Aquifer pumping tests performed in two wells screened across this aquifer system indicated a hydraulic conductivity of 205 and 390 gpd/ft^2 (assuming the screened interval in the wells was equivalent to the total thickness of the aquifer); the storage coefficient was estimated to be 1.1×10^{-3} and 9.6×10^{-4} (Boyle, 1990). Hydraulic conductivity values of 100 to 150 gpd/ft^2 were used for the corresponding aquifer in the calibrated IGSM for the Northern American River service area (Montgomery Watson, 1995).

The shallow aquifer system is underlain by Miocene-Pliocene clastic deposits of volcanic origin, known as the Mehrten Formation, that comprise the deeper semi-confined aquifer. The City of Lincoln municipal wells No. 2 and No. 4 appear to be constructed such that groundwater is produced from below the Laguna Formation, within this aquifer. Underlying the Mehrten Formation is the Ione Formation, an Eocene marine deposit that in parts of the Lincoln SOI, where it is shallow, contains fresh water, but otherwise contains brackish or saline water.

MEHRTEN FORMATION

The Mehrten Formation is composed of a sequence of late Miocene through middle Pliocene fragmental volcanic rocks that unconformably overlie Eocene marine and brackish water sediments. The formation consists of two distinct units:

- A sedimentary unit containing fluvial deposits composed of gray to black well-sorted sands with associated lenses of stream gravels containing cobbles and boulders, interbedded with blue to brown silts and clays

- A dense, hard gray andesitic tuff-breccia formed by the solidification of ash mudflows emanating from volcanic eruptions to the east

The sand and gravel beds within the sedimentary unit, which are individually 5 to over 20 feet thick, are highly permeable and saturated with primarily fresh water. Consequently, the sedimentary unit of the Mehrten is recognized as an important aquifer in much of the Sacramento Valley, producing significant fresh groundwater supplies throughout much of the Placer and Sacramento County regions. In contrast, the tuff-breccia, which ranges from a few feet to 30 feet thick, generally is impervious and acts as a confining layer where it occurs. DWR investigators indicate that, on a regional scale, the upper surface of the Mehrten Formation trends deeper from north to south (DWR, 1995). The Spectrum-Gasch investigation (1999) shows the Mehrten Formation, in the localized Lincoln SOI area, to be gently dipping westward (the dip estimated to be about one degree), and increasing in overall thickness with depth below surface.

IONE FORMATION

The Eocene Ione Formation lies below the Mehrten Formation, except in parts of the Lincoln SOI it unconformably underlies the Riverbank Formation and the Mehrten formation is absent. This unit contains marine deposits consisting of white to light yellow colored conglomerate, sandstone, and claystone. The Ione is recognized as the light colored clay visible in the Gladding-McBean quarry north of Lincoln. As the depth of the Ione Formation increases it has been recognized that water quality in this formation becomes poor, or more saline. The Boyle Engineering Corporation investigation of 1990 conducted for the City of Lincoln identified the contact between the Mehrten and the Ione Formations as the base of fresh water in the vicinity of Lincoln Airport. The Ione Formation has not been used extensively for groundwater production due to its generally low water yield and mostly poor water quality.

Groundwater Movement

Groundwater levels and flow direction in the Lincoln area have remained relatively stable through the period of historical record (approximately 1950 to present). The regional groundwater flow direction is west-southwest, approximately parallel to Coon Creek in the northern part of the Lincoln area and southwesterly through most of the Lincoln SOI. The sedimentary section comprising the aquifer systems dips to the west-southwest as well, at about five degrees or less – suggesting the unstressed groundwater flow direction is parallel to the slope of geologic bedding (Spectrum-Gasch, 1999). There is not enough monitoring well data to define the groundwater elevation contour map and, correspondingly, groundwater flow direction at a more localized scale throughout the Lincoln area. The City of Lincoln has plans for installing a monitoring well network throughout the Lincoln SOI.

In order to determine groundwater velocity it is necessary to know the groundwater gradient (change in level over distance) and the hydraulic conductivity and porosity of the aquifer material. While these parameters are not well defined across the Lincoln SOI, an estimate of representative groundwater velocity can be calculated for the area in the vicinity of the City of Lincoln Well No. 2 and Well No. 4 shown on Figure 3, near the airport. Figure 3 shows groundwater elevation contours across this area computed from late March 2003 measurements in DWR monitored wells. The groundwater gradient is approximately 0.001 feet horizontal distance per foot change in groundwater level. Boyle (1990) measured a hydraulic conductivity of 205 and 390 gpd/ft^2 in two wells in the airport vicinity that were apparently completed in the lower aquifer system (the Mehrten Formation). Taking the average of the two (298 gpd/ft^2) and assuming an average effective porosity of 15%, the average groundwater velocity is about 0.3 feet per day. Using the same inputs for representative groundwater gradient and porosity applied for the range of reported hydraulic conductivities from above-mentioned studies, the corresponding range in average groundwater velocity for the two aquifer systems is:

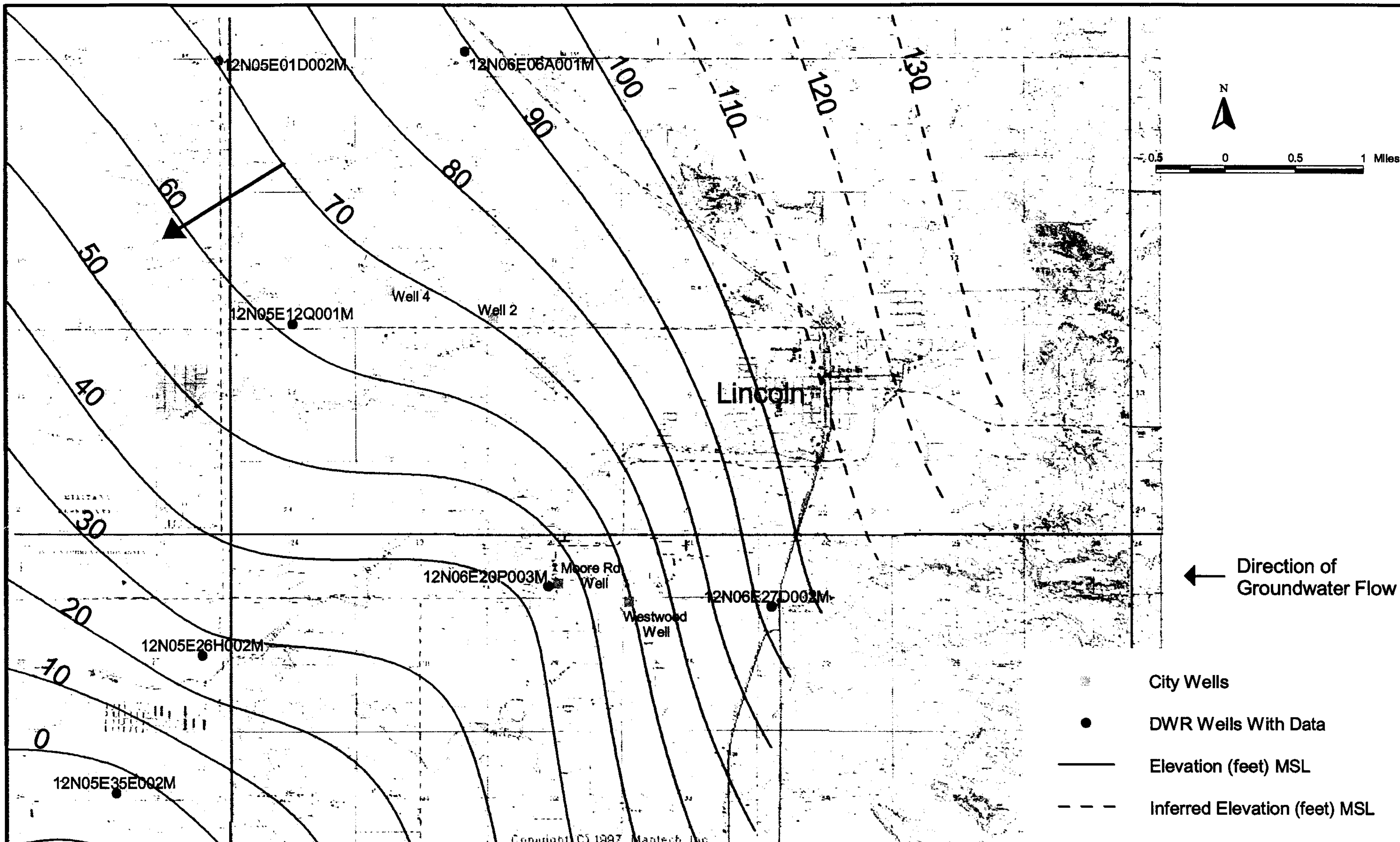
- Upper aquifer system: 0.07 to 0.7 feet per day
- Lower aquifer system: 0.1 to 0.4 feet per day

Hydrographs from DWR monitored wells in the Lincoln area show no systemic decrease in groundwater levels since 1960 (a description of individual DWR monitoring well hydrographs is provided in the next section).

The stability of groundwater levels in the Lincoln area over historical hydrologic conditions is demonstrated by the Integrated Groundwater and Surface Water Model (IGSM) simulation study performed for the American River Water Resources Investigation (DWR, 1995). The Northern American River Service Area IGSM model was used to simulate groundwater levels on a monthly time-step over the period 1922 to 1992, with water demands at 1992 level of development and crop acreage at the 1990 level. Simulated groundwater level, averaged for the two aquifer systems, at a model node just north of Lincoln indicates no systematic change over the period, only seasonal variations.

Furthermore, another IGSM study performed as part of the American River Water Resources Investigation (USBR, 1994) indicates that even under projected 2030 water use demand, wherein unrestricted groundwater use is permitted to meet demand unmet by full delivery of surface water entitlements, simulated groundwater levels in the Lincoln area do not decline, on average, during 1922 to 1991 hydrologic conditions.

Other areas of the North American Groundwater Subbasin have experienced significant declines in groundwater levels due to pumping extraction from the subbasin's aquifer systems. In particular, there is a deep cone of depression centered



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Groundwater Elevation Contours and General Flow Direction (March 2003)

City of Lincoln
Groundwater Management Plan

Figure 3

Date: September 2003

Prepared By: BCW

in northern Sacramento County near McClellan Air Force Base that extends into southwestern Placer County – as far north as about Pleasant Grove and as far east as about Roseville. This deepening cone of depression and the implications on the areas affected are discussed in the West Placer Groundwater Management Plan (PCWA, 1998). The cone of depression does not appear to extend to or impact the Lincoln SOI at this time.

An aggregate mine has been proposed four miles north of Lincoln that will eventually excavate pits covering approximately 1,000 acres over the 85 year expected life of the mining operation. The mine would excavate and process sand, gravel, and granitic rock, creating a 45-foot deep pit for the alluvial material and a 150-foot pit for the granite. The pits will require dewatering and will be mined for periods of 35-40 years for alluvium and 85 years for granite. The plan is to reclaim this land as lakes, agriculture land, open space, and habitat areas. One of the primary concerns is the impact the dewatering will have on groundwater conditions in the area. The project plan proposes to help keep the impact on groundwater levels small by placing a low permeability overburden (e.g. clay) around the sides of pits as mining proceeds. The groundwater modeling study (Luhdorff and Scalmanini, 1997) of the proposed project impact concludes that there will be lowered groundwater levels in the immediate vicinity of each mining pit, but groundwater levels south of Wise Road and east of Highway 65 will not be affected. The study also shows that minor reductions in streamflow from lowering of the groundwater level will mostly be compensated for by the addition of water from the dewatering. These conclusions have not been substantiated.

The City of Lincoln is planning to install additional pumping wells within the Lincoln SOI to be able to ultimately meet a 20 million gallon per day (MGD) demand with groundwater on a short-term basis. The increase in pumping will likely have an effect on local groundwater levels. The overall impact of the additional wells will depend on the well placement and depths, and the well pumping rates and schedules. The City has an ongoing groundwater investigations to help determine optimal well spacing and pumping schedules, and to predict any significant the impact on groundwater conditions. The investigation includes drilling a number of boreholes, collecting logs of the lithology, conducting geophysical tests and small and large scale well pump tests. Three test holes were drilled in the summer of 2003 and completed as monitoring wells once the lithologic and geophysical testing were complete. Drilling of two additional boreholes is planned for completion by summer

2004. After testing is complete the boreholes will be completed as municipal production wells. Aquifer pump tests are planned for the completed wells.

Recharge

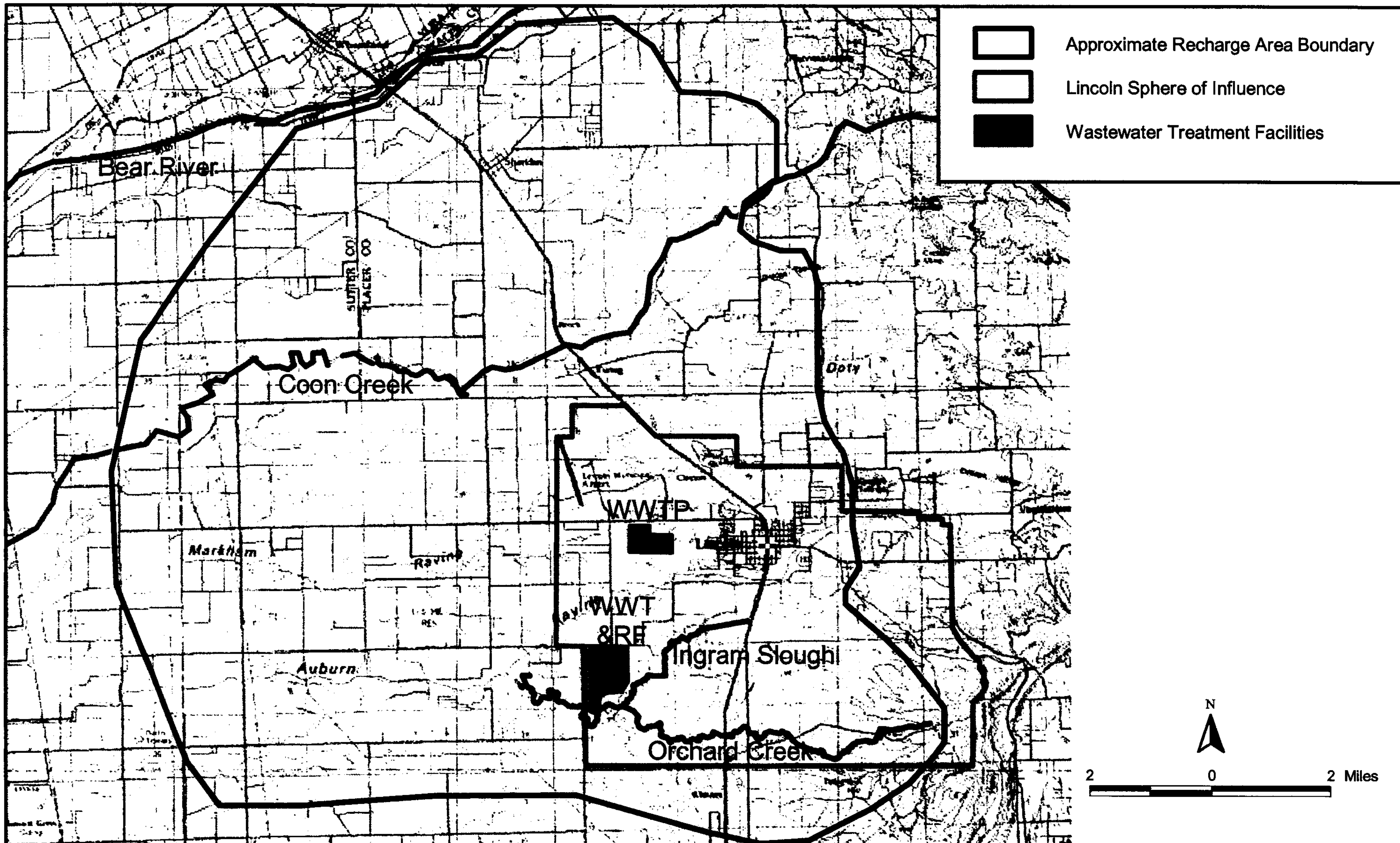
A comprehensive study of groundwater recharge area and rates specific to the Lincoln SOI has not been performed to date. The technical definition of a recharge area is where water enters the saturated zone and has a net downward flow direction (Freeze and Cherry, 1979). Thus, to precisely define recharge areas it is necessary to measure the shallow groundwater head gradient in three dimensions across the groundwater basin – in essence requiring groundwater level measurements in a densely spaced monitoring network of wells, each containing piezometers in each aquifer unit. In practice, the direct measurement of a groundwater basin's recharge area is impractical and instead a combination of monitoring well data and indirect methods of inference are employed to delineate probable recharge areas. Currently, there are several indirect indicators of the potential recharge areas within the Lincoln SOI, which are discussed below. With the planned development of a monitoring well network, a more refined delineation of recharge areas should be possible.

The runoff characteristics and recharge potential of the soil throughout the Lincoln area have been investigated and mapped – providing a qualitative indication of the areal potential for deep percolation of surface water into the aquifer systems. Most of the soil cover across the North American Subbasin has been classified as having high runoff (low infiltration) potential, except in the vicinity of river and stream drainages (Montgomery Watson, 1995). A fairly large area surrounding Auburn Ravine, as well as Coon Creek, has been classified as having soils with moderate to high runoff potential (low to moderate infiltration potential). DWR (1995) characterizes the soil cover across the area as having a dense subsoil that limits deep percolation of water applied at the surface; less dense soils occur in the vicinity of creeks such as Coon Creek and Auburn Ravine, providing better deep percolation and recharge. Boyle (1990) also identified the Markham Ravine drainage as a probable area of groundwater recharge and Spectrum-Gasch (1999) identified the Orchard Creek drainage, along with Auburn Ravine, as probable areas of significant recharge based on the inferred shallow depth to the upper aquifer zone in these areas.

Figure 4 displays the surface recharge area boundary likely encompassing all the surface areas that potentially could contribute recharge water to the aquifer systems within the Lincoln SOI – under existing pumping demands, as well as those that would likely occur with the City of Lincoln's planned additional groundwater extraction. The eastern boundary of the area marks the geologic contact between the alluvial sediments of the groundwater basin and the non-water bearing basement rocks of the Sierra foothills. The northern boundary is the Bear River drainage that is a probable shallow hydrologic divide, with groundwater flow occurring predominantly parallel to the river and, thus, most of the groundwater to the north of the river never flowing south of the river. The southern boundary of the denoted recharge area was selected to roughly correspond with the southern extent of the Orchard Creek and Auburn Ravine drainages – probable areas of significant groundwater recharge – and is positioned closer to the City of Lincoln than the northern boundary because flow is in a predominantly southwesterly direction through this area (away from Lincoln). The western boundary was selected at an arbitrary distance significantly down gradient of the SOI to represent a conservative estimate of the extent of recharge area to the west.

Most of the recharge within the boundary is likely occurring in the vicinity of the stream drainages, as discussed above. The recharge areas will be more specifically identified by looking at the pattern of groundwater levels versus well depth throughout the area as part of the continuing City of Lincoln groundwater resources investigation.

Quantitative estimates of groundwater recharge rates by type (e.g. stream recharge, deep percolation) for subregions of the North American Subbasin were calculated using the Montgomery Watson 1995 IGSM model developed as part of the baseline study. The modeling study itemizes the groundwater budget for the period from 1970 to 1990, including all major types of recharge into and discharge from the aquifer systems, but the accounting is not provided for the specific area incorporated in the Lincoln SOI. Table 2 shows the 1970 to 1990 average simulated groundwater budget for the two subregions in the model that include the Lincoln SOI: Subregion 5 is located just north of downtown Lincoln (3962 acres). Subregion 6 encompasses the southern and western portions of the Lincoln SOI, as well as a 24,508 acre area to the west of the SOI (Montgomery Watson, 1995).



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Approximate Recharge Area Boundary for Lincoln

City of Lincoln
Groundwater Management Plan

Figure 4

Date: October 2003

Prepared By: BCW

Table 2: Average Simulated Groundwater Budget 1970–1990

Groundwater Inflow/Outflow Component	Subregion 5 (acre-feet/year)	Subregion 6 (acre-feet/year)
Deep Percolation	3,194	20,133
Gain from Streams	0	3,903
Boundary Inflow	832	2154
Other Recharge	0	1,930
Pumping Extraction (Outflow)	(-3,877)	(-28,393)
Change in Storage	149	(-273)
Max. Decrease in Storage for 1 year	-1,668 in 1977	-20,012 in 1977
Max. Increase in Storage for 1 year	2,041 in 1983	15,171 in 1982
1990 Storage	15,700	559,900

The IGSM model predicts that most of the groundwater recharge into the two combined model subregions is due to deep percolation (78%), followed by gain from streams (13%). The areal distribution of the simulated deep percolation is not reported and, thus, the contribution from the Auburn Ravine, Coon Creek, and other stream drainage areas versus outlying areas cannot be determined. The IGSM groundwater budget suggests that deep percolation is the major contributor to groundwater recharge, which is in contradiction to the soil mapping results, described above, which show a predominance of high runoff / low infiltration soil cover and, consequently, low potential for deep percolation recharge. The reason for this discrepancy is not clear and highlights the need for a more comprehensive investigation of groundwater recharge in the area.

A simple approximation of the simulated groundwater recharge into the actual Lincoln SOI for each subregion can be made by multiplying the recharge component by the fraction of the subregion area in the Lincoln SOI. Using this approach, the approximate total simulated groundwater recharge into the aquifer systems underlying the Lincoln SOI, averaged over the period 1970-1990, is 16,875 acre-feet/year, of which 12,302 acre-feet/year occurs as deep percolation and 1952 acre-feet/year as inflow from streams, 1659 acre-feet/year from boundary inflow and 965 acre-feet/year from other sources.

As part of the groundwater management planning process, a useful future study will be to refine and recalibrate the simulation model using updated information about local Lincoln area groundwater conditions followed by additional simulation runs using historical precipitation and streamflow records with current applied water demands. As part of this modeling study a sensitivity analysis of input hydrogeologic parameters (e.g. soil and streambed permeability) should be performed to determine the range of values across which they can vary and still produce acceptable model results. Such a study would estimate the groundwater budget (recharge and discharge components, and change in storage) of the aquifer systems directly underlying the Lincoln SOI across a range of realistic conditions. In addition, modeling runs could be made using estimated future demand scenarios to assess the potential impact of additional pumping wells on groundwater conditions.

Estimated Groundwater Quantity

A recent investigation of groundwater resources in the Lincoln SOI mapped the top and base of the upper aquifer sequence across much of the SOI area using fairly widespread geophysical surveys and drill hole data to give a more accurate picture of the sub-surface lithology (Spectrum-Gasch, 1999). Survey and drill hole data included:

- Well logs, geophysical (electric) logs, and/or pumping data from approximately 200 borings[3]
- 67,000 feet of seismic reflection data and 12,000 feet of seismic refraction data (geophysical methods performed along survey lines that provide a cross-section image of the subsurface)

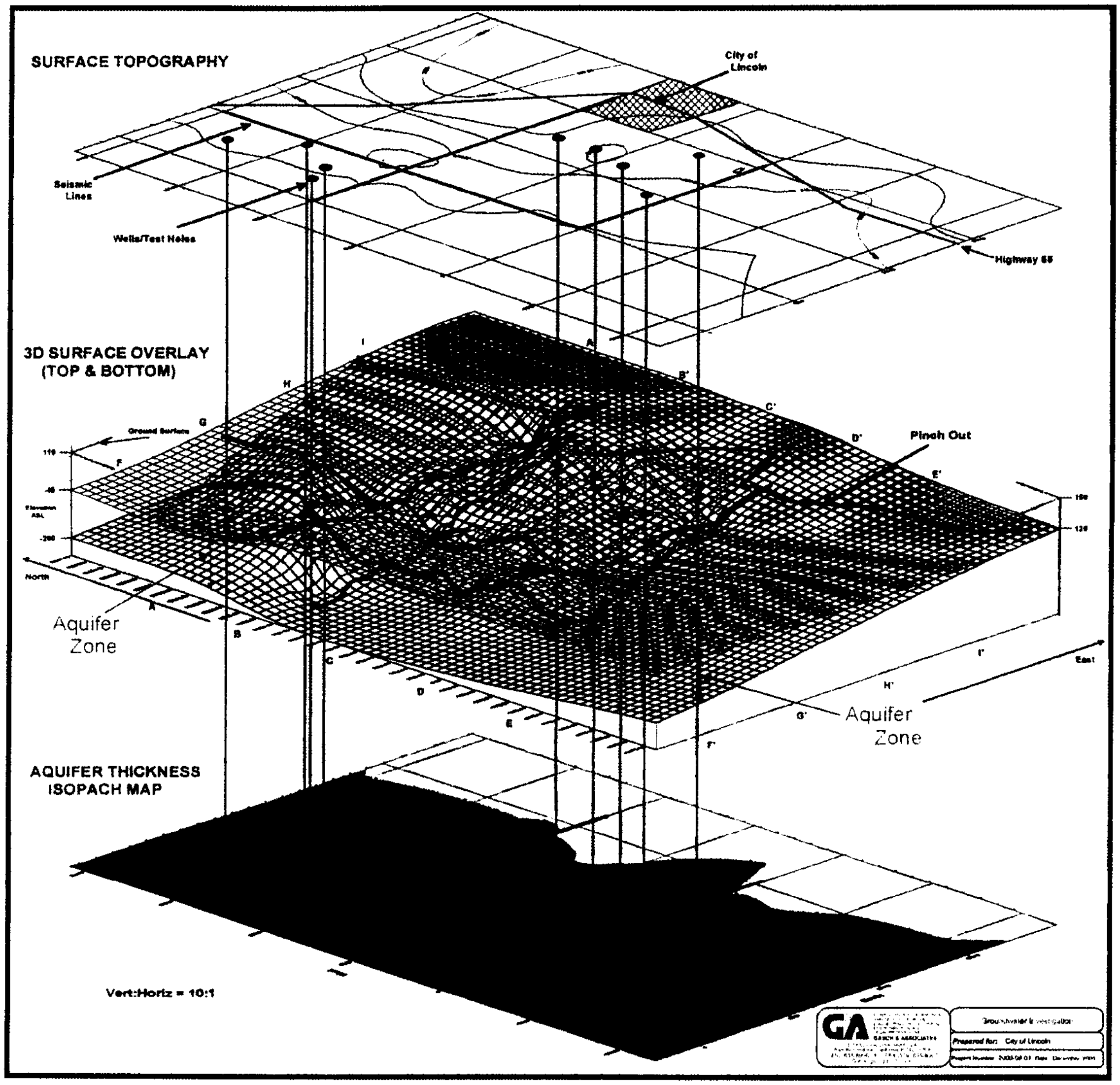
Figure 5 shows the resulting composite three-dimensional model of the underlying aquifer as calculated based on the data available to the investigators.

[3] Information derived from the well logs has been translated into a database. A summary of the database is included in Section 3.

Figure 5: Lincoln Aquifer System Model

(Figure provided by Gasch and Associates)

Three Dimensional Model



The investigators used the processed geophysical surveys and well data to map what they refer to as the upper productive aquifer zone within the Lincoln SOI – the base of the zone defined by the top of the Mehrten Formation tuff/breccia unit or a thick clay layer and the top of the zone defined by the bottom of a surficial clay-rich layer. The results indicate the productive zone pinches out to the east, along a north-south line close to Highway 65. East of this line the likely potential water bearing formations are the Ione Formation and fractured granitic bedrock. West of this line the productive aquifer zone thickens westward, although there are localized variations in thickness. There are also known variations in the presence and number of clay interbeds and in the hydrologic properties of the aquifer zone, but these properties cannot be determined from the data. The thickness of the upper aquifer system exceeds 300 feet near the western boundary of the Lincoln SOI, south of Lincoln Airport.

Spectrum-Gasch used the results of their investigation to calculate a conservative estimate of groundwater reserves underlying the 25,200 acre Lincoln SOI. They inferred that approximately 9,000 acres of the SOI is underlain by the productive aquifer zone, predominantly in the western two miles. They assumed a nominal total aquifer thickness of 100 feet across this area, producing 900,000 acre-feet of total aquifer volume. They then assume an average porosity of 15% and recovery factor of 50% (this is the same as a specific yield of 7.5%), resulting in a volume of 67,500 acre-feet of recoverable groundwater. This yield is reduced by 30% to account for discontinuities in the aquifer zone, such as interbedded clay, leaving an estimated total recoverable groundwater volume of 47,250 acre-feet.

The Northern American River Service Area IGSM modeling study (Montgomery Watson, 1995) modeled the aquifer systems as two semi-confined aquifers. Within the Lincoln SOI the two aquifers pinch out east of Lincoln and increase in thickness to the west-southwest, having a maximum thickness of about 140 feet (upper aquifer) and 175 feet (lower aquifer) at the western edge of the SOI. As part of the model calibration for the baseline study the total volume of groundwater stored within the aquifer system at the end of 1990 is reported for specified subregions of the model, two of which include the Lincoln SOI (see Table 2 above). At the end of 1990 total groundwater storage of the aquifer systems underlying the Lincoln SOI was approximately 290,940 acre-feet, based on a simple summation of the approximate fraction of the area in each model subregion that is within the Lincoln SOI multiplied by the storage in that subregion; this approximation assumes the storage is equally distributed across the model subregion. Other important modeling results include:

- The average change in storage across the Lincoln area is small, suggesting the localized groundwater system is stable over the long term (see Table 2 above)
- Year-to-year variations in storage across the Lincoln area are quite large, suggesting the groundwater system is sensitive, and responds quickly, to

variations in annual precipitation and the resulting changes in groundwater usage (see Table 2 above).

There is a significant discrepancy between the two estimates of groundwater storage in the Lincoln SOI derived from the geophysics and well data study (Spectrum-Gasch, 1999) and the ground-surface water simulation model study (Montgomery Watson, 1995). The Spectrum-Gasch prediction of recoverable groundwater is only 16% of IGSM model estimate of total groundwater storage. The difference is likely due to a number of factors:

- The Spectrum-Gasch study only considers what they call the upper productive aquifer zone, which probably somewhat corresponds with the upper aquifer system as defined for the North American Subbasin and used in the IGSM model. The IGSM model also includes the lower aquifer system.

- Spectrum-Gasch assumes an average saturated aquifer thickness of 100 feet across the area where it occurs, even though the thickness in their three-dimensional model varies between zero and over 300 feet.

- Spectrum-Gasch assumes an average specific yield of 7.5% whereas the IGSM model specific yield is between 8% and 12%.

- Spectrum-Gasch considers the aquifer zone to be discontinuous, containing a total of 30% by volume of non-aquifer material, whereas the IGSM model assumes the aquifer is continuous.

- Spectrum-Gasch assumes 50% of the groundwater is recoverable.

The discrepancy between the two estimates can be explained by the different assumptions used in developing the two estimates. Applying the assumptions used by Spectrum-Gasch to the Montgomery Watson estimates brings the two estimates to within approximately 5% to 10% of each other.

A reasonable conclusion is that these two estimates represent approximate lower and upper limits of the total recoverable groundwater storage; this large range in possible values could be considerably reduced with better estimates of aquifer geometry and aquifer hydrologic properties. The simulation model does not include the new information provided by the Spectrum-Gasch investigation. The model can be refined and recalibrated over the Lincoln area with the addition of this and future information; then the groundwater budget could be recalculated, this time to correspond to the boundaries of the Lincoln SOI, to generate much more robust estimates of groundwater storage, as well as recharge and discharge components. The City is currently planning to develop such a surface water – groundwater model.

Documentation of Non-Overdraft Conditions

The City of Lincoln overlies the North American Subbasin (Basin), which is part of the larger Sacramento Valley Groundwater Basin. DWR documentation was reviewed to determine if DWR has identified the portion of the groundwater basin underlying the City to be in a state of overdraft, or if any DWR documentation has projected overdraft within the Lincoln Sphere of Influence. The following DWR documents were reviewed for this analysis: Bulletin 118-80 (DWR, 1980), Bulletin 118-3 (DWR, 1974), Bulletin 118-6 (DWR, 1978), and the draft basin description for the Bulletin 118 Update (DWR, 2002a). Additional historical groundwater elevation data collected by DWR was reviewed for wells within the City of Lincoln's designated Sphere of Influence. The period of record for each well was plotted and included in this analysis.

Analysis of data collected by the California Department of Water Resources indicates that groundwater levels in the Lincoln area have been stable since the 1920's

Generally, the documents reviewed describe conditions of overdraft in southwestern Placer County and northern Sacramento County, located to the southwest of the City of Lincoln. Groundwater elevations directly underlying the City were not described to be in a long-term state of decline. Groundwater elevation data, presented in the following section, support the conclusion that groundwater elevations are not declining within the vicinity of Lincoln.

Bulletin 118-80

Bulletin 118-80 examined groundwater basins in the state of California and designated basins in a state of critical overdraft. Bulletin 118-80 did not designate the portion of the groundwater basin underlying Lincoln as critically overdrafted. The report did find the portion of the Sacramento Valley Basin located in northern Sacramento County as critically overdrafted. This area is located to the southwest of the City of Lincoln.

Bulletin 118 Update 2002

Draft documentation located on the DWR website for the Bulletin 118 Update 2002 was reviewed for the North American Groundwater Subbasin. The report cited Placer County Water Agency (1999) as finding that "groundwater elevations in southwestern Placer County and northern Sacramento County have generally decreased, with many wells experiencing declines at a rate of about one and one-half feet per year for the last 40 years or more." This area is southwest of Lincoln and the decline in water elevation does not extend to the Lincoln SOI.

Bulletin 118-3

Bulletin 118-3 evaluates groundwater resources in Sacramento County. While the document does not specifically discuss groundwater conditions in Placer County the document does show a cone of depression in groundwater elevation for northern Sacramento County in the spring of 1968. The center of the cone of depression is located approximately 20 miles to the southwest of Lincoln.

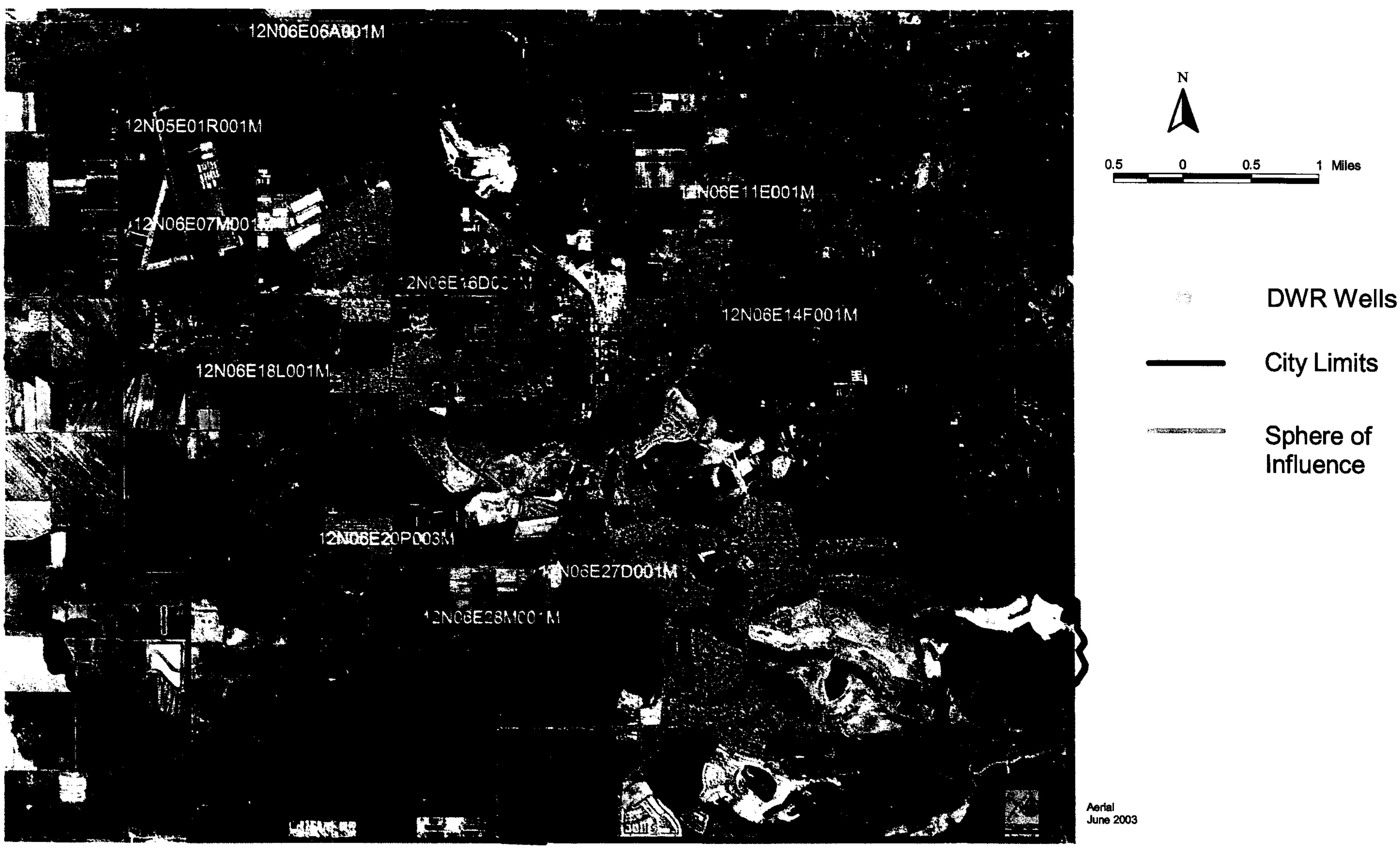
Bulletin 118-6

Bulletin 118-6 evaluates groundwater resources in the Sacramento Valley. Groundwater contours within this document, and supporting documentation: *Groundwater Conditions in the Sacramento Valley, California, 1912, 1916, and 1971,* show a cone of depression in groundwater elevations located in northern Sacramento County and southwestern Placer County. The center of the cone of depression is located approximately 20 miles to the southwest of Lincoln.

Historical Groundwater Elevations

Groundwater level data was downloaded from the DWR Water Data Library (**http://well.water.ca.gov**) for all wells monitored by DWR within the City of Lincoln's designated Sphere of Influence (DWR, 2002a). Figure 6 displays the location of each well along with the city limits and Sphere of Influence. Figures 7 - 16 display the historical groundwater elevations for each well. As shown in the figures, over the past 40 years groundwater elevations underlying Lincoln have remained relatively stable.

Only 3 wells have monitoring data that are current. The Department of Water Resources has discontinued monitoring of the remaining 7 wells.



DWR Monitored Wells With Water Elevation Data

City of Lincoln
Groundwater Management Plan

Figure 6

Date: October 2003

Prepared By: BCW

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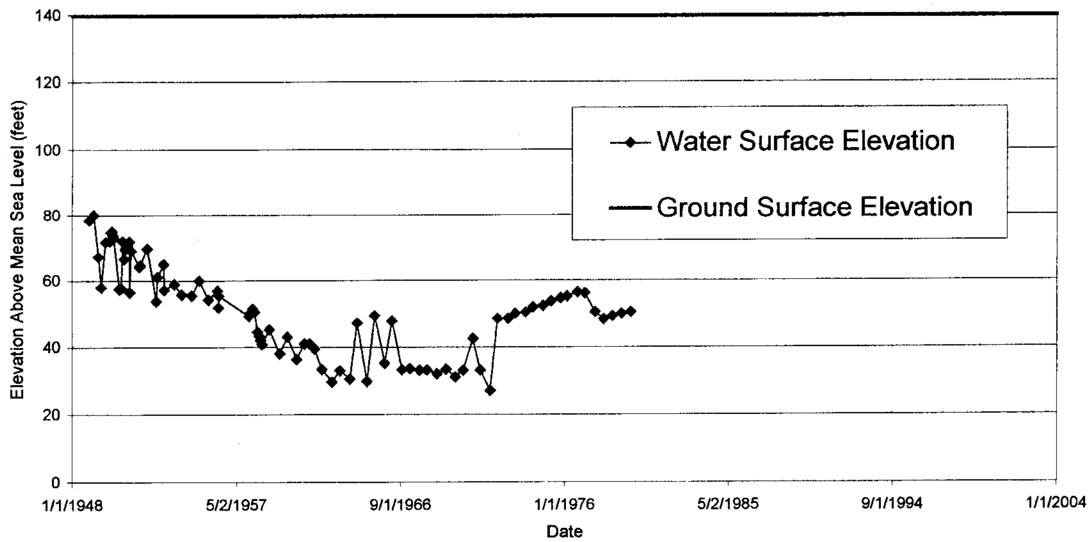


Figure 7: Water Surface Elevation for State Well Number 12N06E27D001M

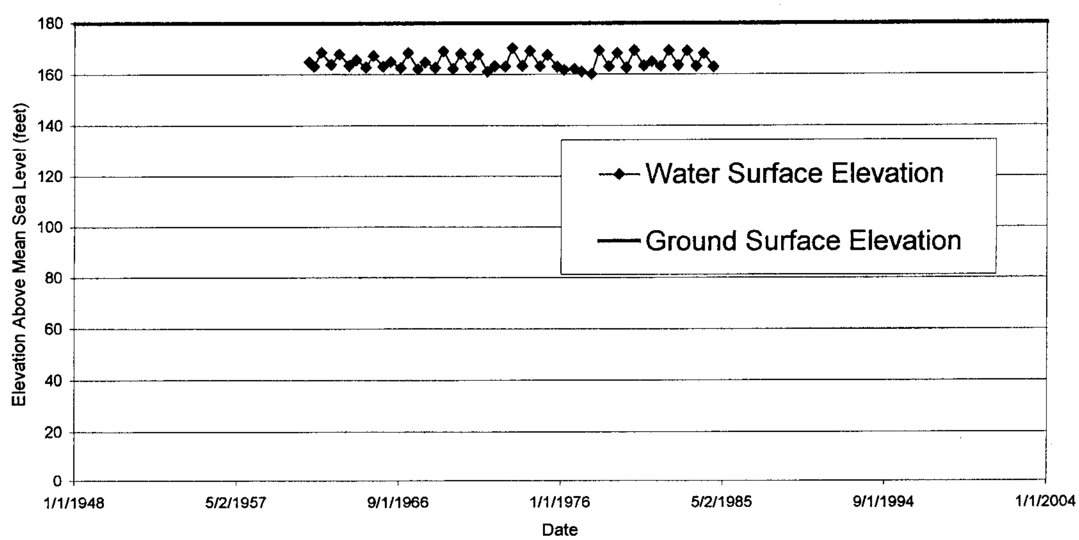


Figure 8: Water Surface Elevation for State Well Number 12N06E14F001M

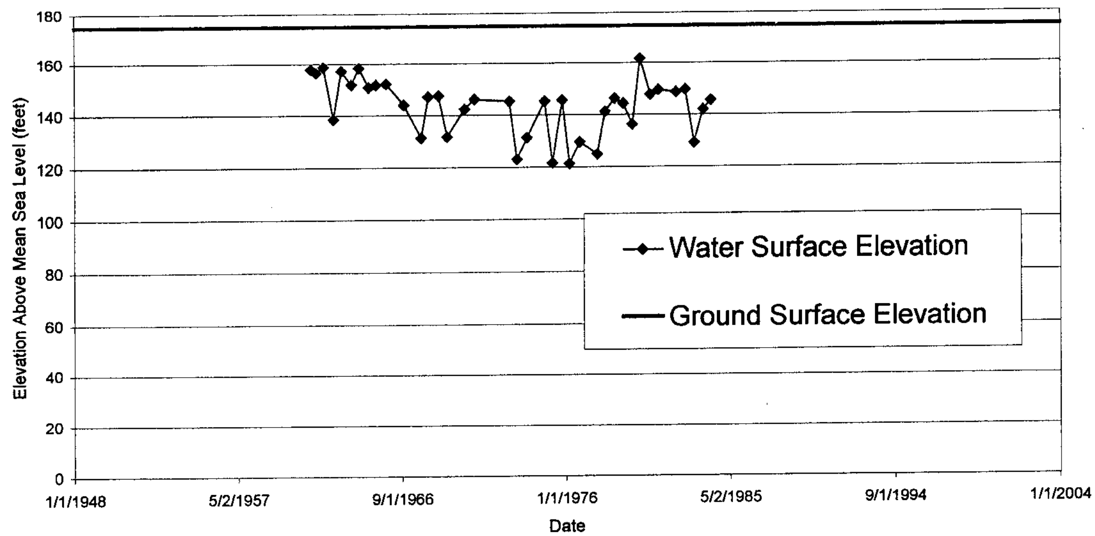


Figure 9: Water Surface Elevation for State Well Number 12N06E11E001M

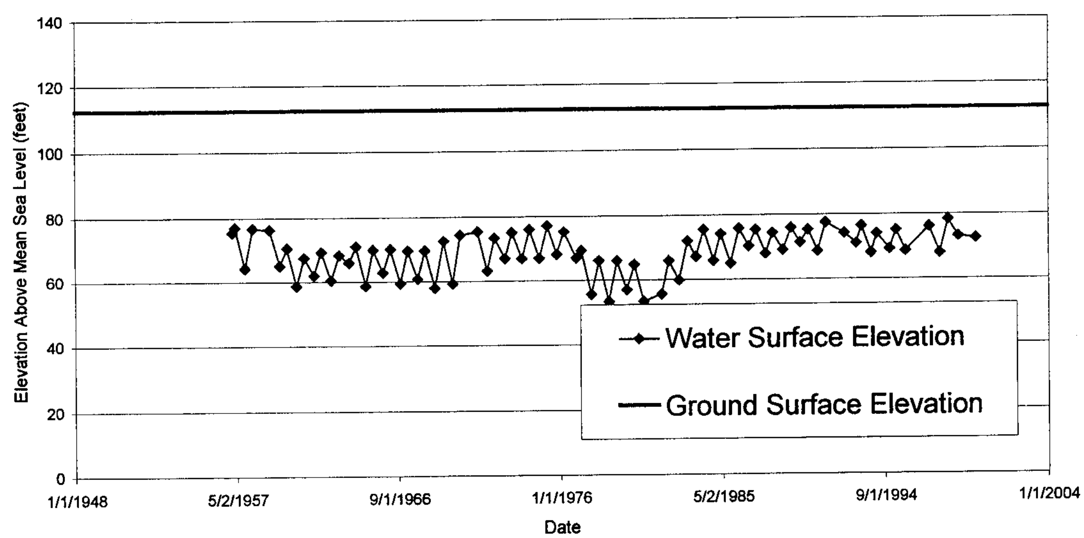


Figure 10: Water Surface Elevation for State Well Number 12N05E01R001M

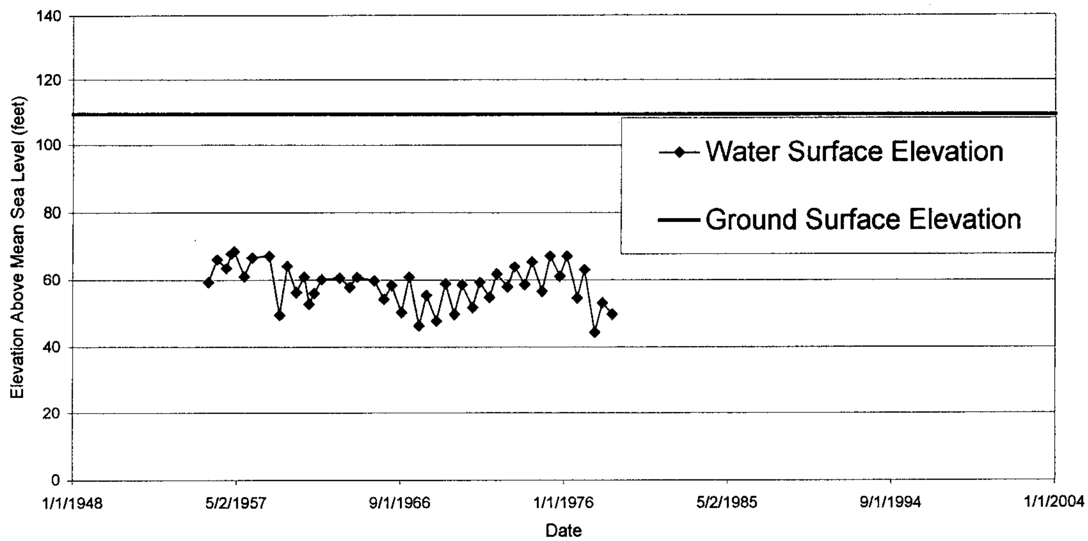


Figure 11: Water Surface Elevation for State Well Number 12N06E07M001M

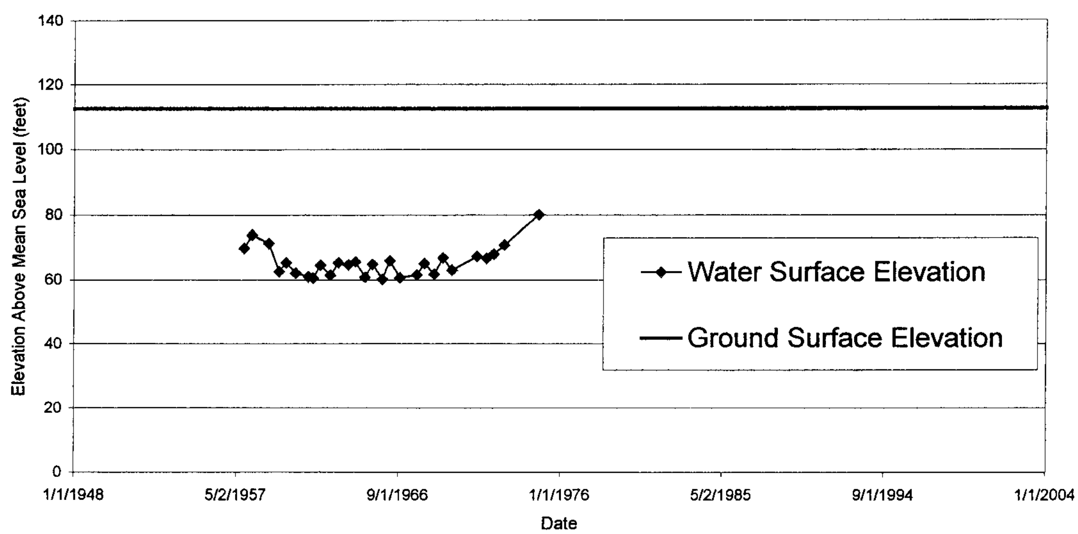


Figure 12: Water Surface Elevation for State Well Number 12N06E18L001M

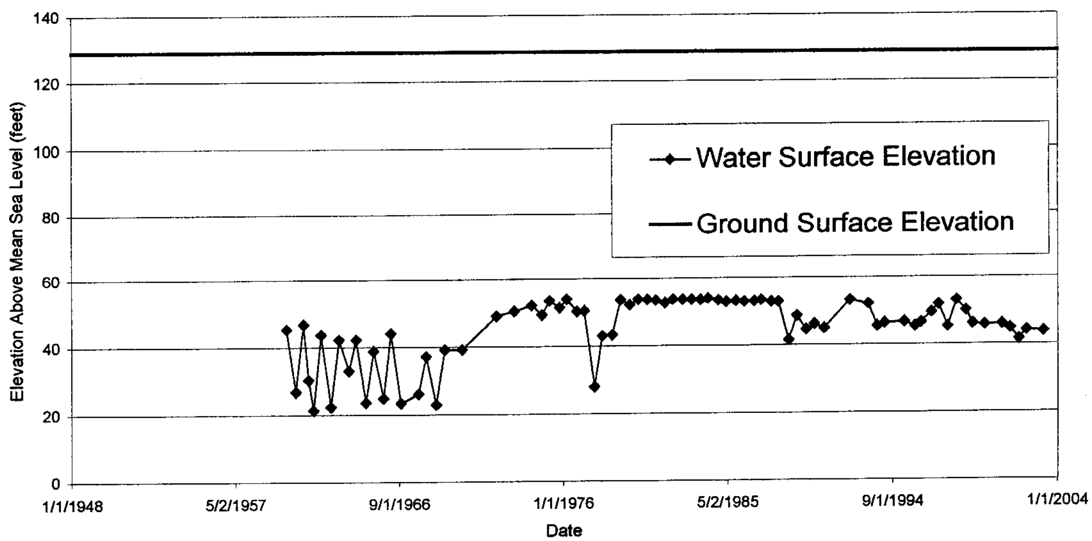


Figure 13: Water Surface Elevation for State Well Number 12N06E20P003M

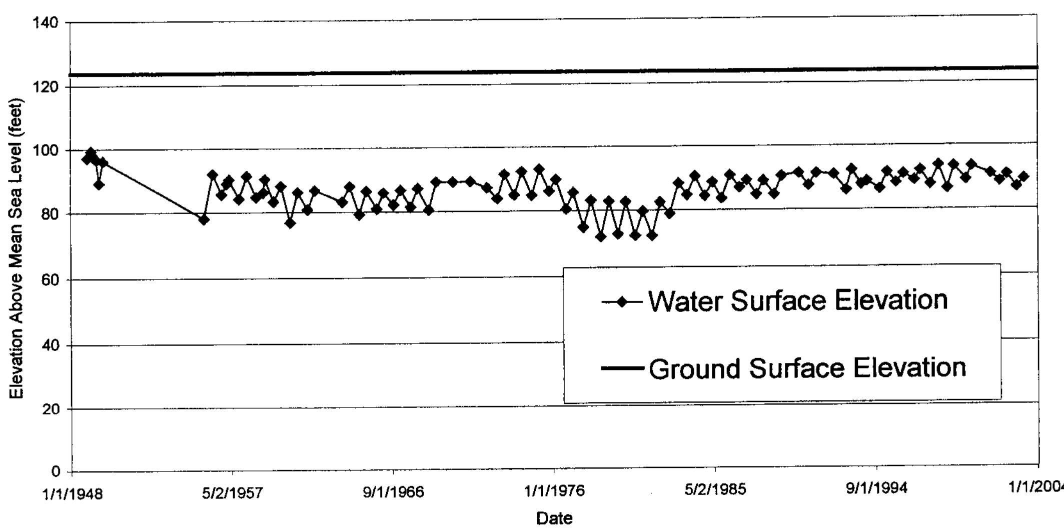


Figure 14: Water Surface Elevation for State Well Number 12N06E06A001M

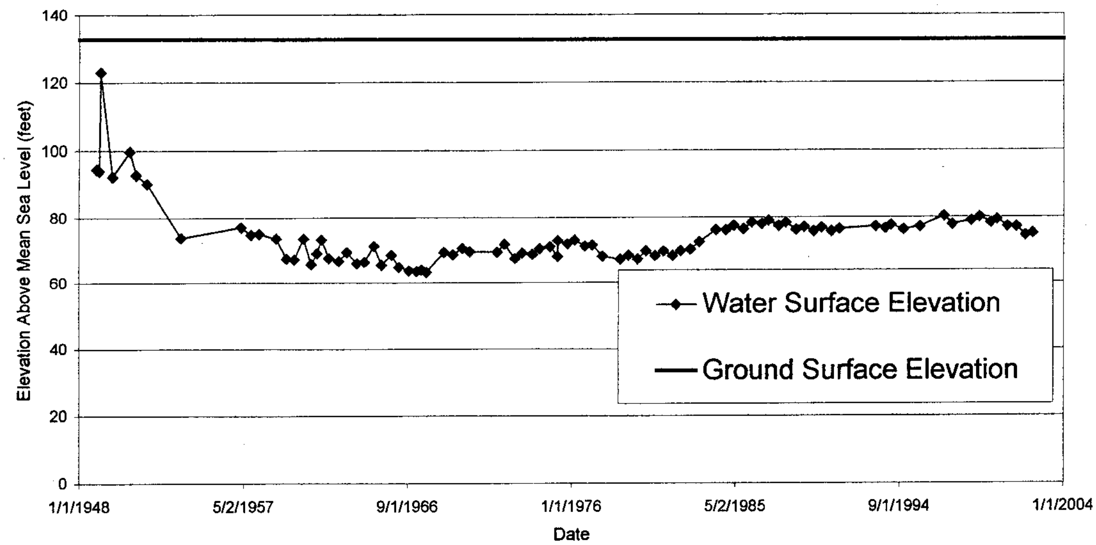


Figure 15: Water Surface Elevation for State Well Number 12N06E16D001M

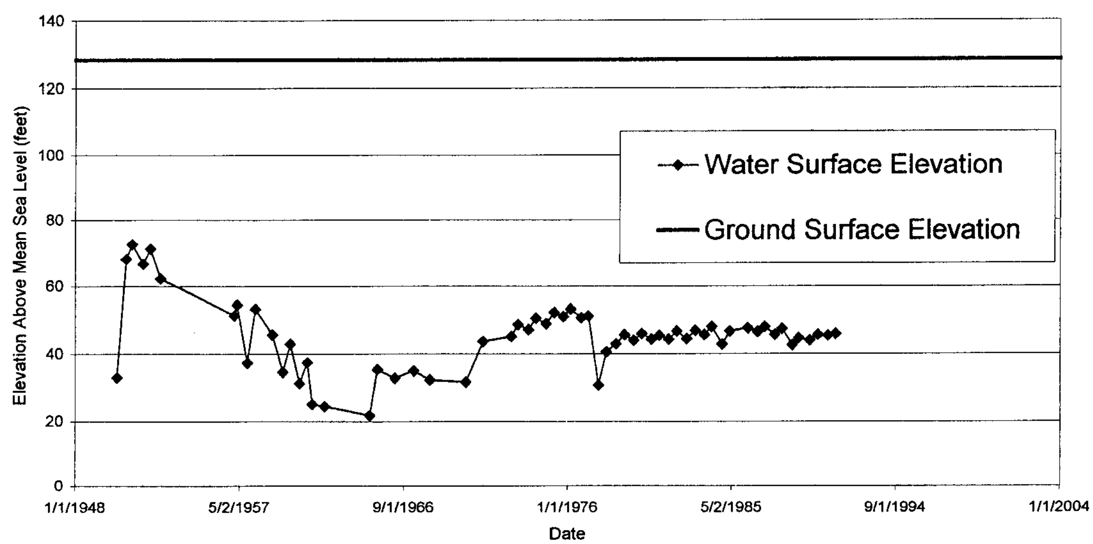


Figure 16: Water Surface Elevation for State Well Number 12N06E28M001M

The three wells that have current elevation data are 12N06E20P003M (Figure 13), located southwest of downtown, 12N06E06A001M (Figure 14), located north of the Lincoln Airport and 12N06E16D001M (Figure 15), located west of downtown and east of the airport. Figures 15 and 16 show a decrease in groundwater elevations during the 1976-77 drought with a subsequent recovery.

Groundwater Quality

Groundwater delivered by the City of Lincoln is regularly tested and meets all primary drinking water standards (City of Lincoln, 2003). Groundwater quality data, summarized from the City's annual CCR is provided in Appendix B.

Nine wells have been installed recently within the Lincoln SOI to conduct aquifer evaluations and to support groundwater model development. The City of Lincoln plans to develop several of these wells into municipal production wells. The remaining wells will be either used for groundwater monitoring or destroyed in accordance with current regulations.

Water quality testing was conducted in the nine new wells. The results indicate that concentrations of some constituents in groundwater are of concern. The constituents include total dissolved solids (TDS), iron, manganese, and arsenic and are discussed in more detail below.

Total Dissolved Solids

TDS concentrations in City of Lincoln wells in production are between 230 and 330 mg/L. The Secondary Maximum Contaminant Level (MCL) concentration of TDS in public drinking water supplies is 500 milligrams per liter (mg/L). Secondary MCLs are set for contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water.

Iron and Manganese

When iron and manganese are present in high concentrations they contribute to plumbing incrustation deposits and surface staining on fixtures. Iron concentrations in the existing City of Lincoln wells range from non-detect (ND) to 1.8 mg/L. Manganese concentrations in the existing water supply wells range from non-detect to 0.07 mg/L. The Secondary MCLs of these constituents in public drinking water supplies are 0.3 mg/L for iron and 0.05 mg/L for manganese. The sources of iron and manganese are naturally occurring.

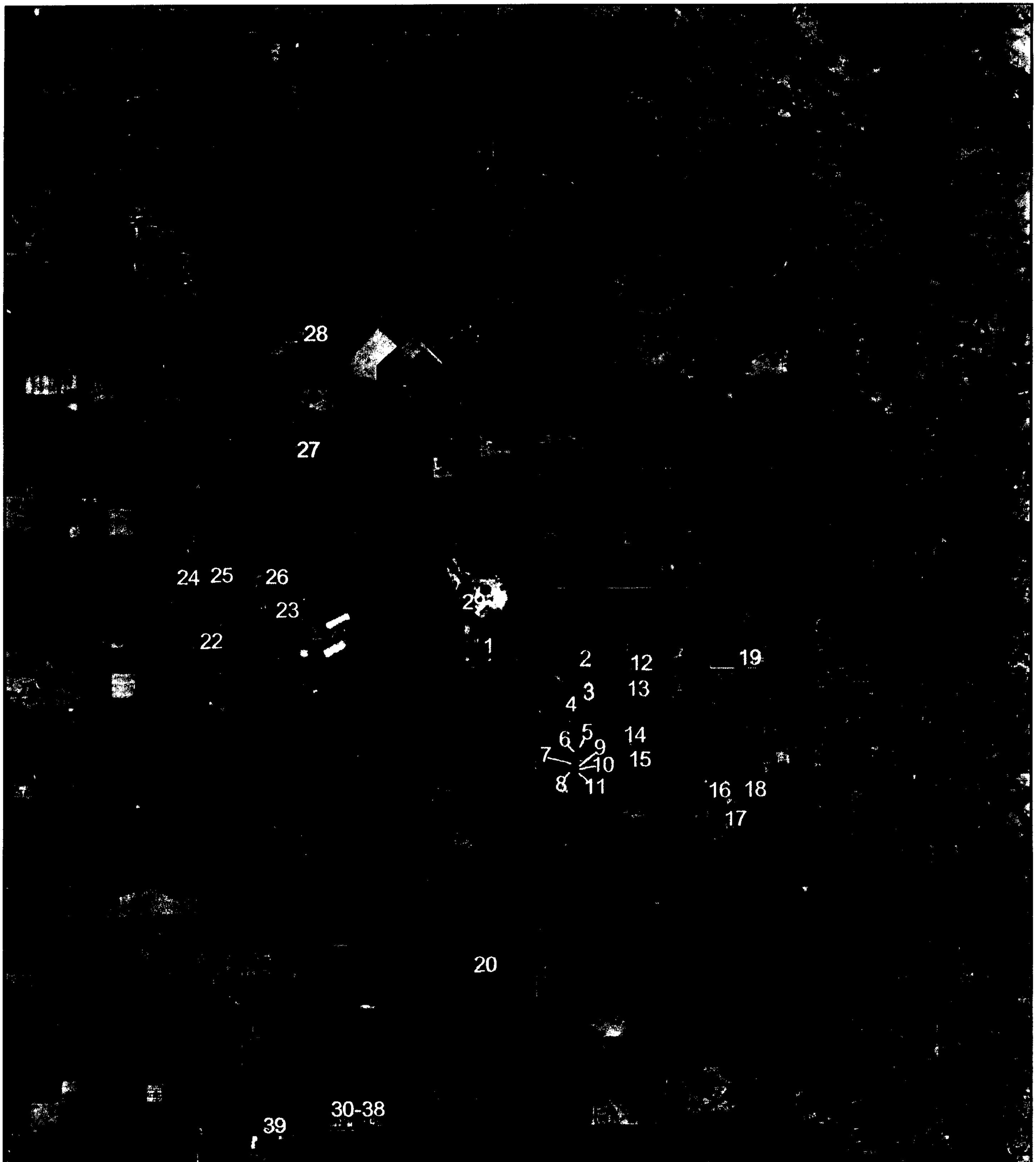
Arsenic

Arsenic concentrations in the City of Lincoln wells range from ND to 4.8 ug/L. The U.S. Environmental Protection Agency is implementing a 10 ug/L standard for arsenic. The source of naturally occurring arsenic in Lincoln groundwater is typically from volcanic deposits.

Regional Groundwater Issues

There are a number of historic, current and proposed activities in and near the Lincoln SOI that have the potential to contaminate groundwater. Locations for some of these activities are depicted in Figure 17 and listed in Table 3. A few of the more prominent sites are discussed below. These activities are not the only potential sources of contamination to Lincoln's groundwater. The activities listed are derived from information provided by Applied Engineering and Geology (AEG, 2003).

Sites shown on the map in Figure 17 represent locations where there has been, is, or may be certain contaminants that have caused or could cause an adverse impact to groundwater within the City's Sphere of Influence. Information to develop this map was compiled from various sources including: Placer County Division of Environmental Health, Regional Water Quality Control Board, GeoTracker Database, AEG's files, Department of Toxic Substance Control, Environmental Data Resources, consultant reports, and others. At certain of these sites, groundwater is known to have been impacted by one or more contaminants, creating a plume of contaminated water that extends some distance away from the source. At other sites, it is known that certain contaminants were or are present in soil at or near the surface, but it is not known that these contaminants have migrated to groundwater. These are, in general, sites where there are no wells that can be sampled to confirm the present groundwater conditions. There are also sites where the presence of certain contaminants is suspected, but no testing has been done to confirm their presence.



Potential Contaminated Sites

Lincoln Sphere of Influence

Teichart (Proposed)

Lincoln City Limits

N

0.5 0 0.5 1 Miles

Saracino·Kirby·Snow
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Existing and Potential Sources of Contamination

City of Lincoln
Groundwater Management Plan

Figure 17

Date: October 2003

Prepared By: BCW

Table 3: Contaminant Activities

Site Number	Site	Primary Government Oversight Agency
1	Industrial	Placer County
2	Landfill	Regional Board
3	Industrial	Regional Board
4	Commercial	Regional Board
5	Commercial	Regional Board
6	Commercial	Regional Board
7	Industrial	Regional Board
8	Industrial	None
9	Commercial	Regional Board
10	Commercial	Regional Board
11	Commercial	Regional Board
12	Commercial	Regional Board
13	Property	Regional Board
14	Property	Placer County
15	Lincoln Corp.	Regional Board
16	Property	Department of Toxic Substances Control
17	County Maintenance Yard	Regional Board
18	Titan Missile Base	Regional Board
19	Closed Lincoln Landfill	Regional Board
20	Ranch	None Currently
21	Ranch	Placer County
22	Lincoln Airport (former Army Air Corp)	Regional Board
23	Lincoln Airport	Regional Board
24	Industrial	Regional Board
25	Industrial	None
26	Industrial	Placer County
27	Industrial	Regional Board
28	Alpha Explosives	Regional Board
29	Industrial	Placer County
30	Commercial	Placer County
31	Commercial	Placer County, Regional Board
32	Commercial	Placer County
33	Commercial	Placer County
34	Commercial	Placer County
35	Commercial	Placer County
36	Commercial	Placer County
37	Commercial	Placer County
38	Commercial	Placer County
39	Western Regional Landfill	Placer County & Integrated Waste Management Board

Alpha Explosives

Alpha Explosives manufactures and retails explosives at a facility approximately five miles north-northwest of the City of Lincoln approximately 1,500 feet north of Coon Creek. Previous practices at the facility resulted in the release of nitrate, perchlorate and ammonium. Nitrate and perchlorate are currently found in local groundwater at concentrations that exceed drinking water standards. The MCL for nitrate is 10 mg/L and the Action Level for perchlorate is 0.004 mg/L. Regular groundwater quality monitoring and reporting for the Alpha site are required by the Central Valley Regional Water Quality Control Board (RWQCB). Nitrate levels in groundwater monitoring wells at the Alpha site are as high as 1,200 mg/L and perchlorate concentrations are as high as 86,000 mg/L (Hydrometrics, 2002). A report produced by Anderson Consulting Group (1999) concluded that nitrate impact to groundwater extends 600 feet to the north and south and 1,300 feet west of the site. Perchlorate impact to groundwater extends 100 feet to the north and south and 650 feet west of the site. The report also concluded that the shallow aquifer underlies the site between the depths of 30 to 100 feet below ground surface. The RWQCB issued a cleanup and abatement order in 1999.

The regional direction of groundwater flow at the Alpha site is to the west. Aquifer tests conducted by Hydrometrics, Inc. (2001) yielded hydraulic conductivity values ranging from 0.1 to 7.5 feet/day.

Teichert Aggregate Facility

Teichert, Inc. is proposing to excavate and process sand, gravel, and granitic resource materials from the Hoffman Ranch and Coon Creek Cattle Company (CCCC) properties located on Coon Creek. The Teichert Aggregate Facility Placer County Project (Teichert Project) is described in the May 1997 report prepared by Luhdorff & Scalmanini Consulting Engineers (LSCE). This project is located in Placer County, approximately four miles north of the Lincoln city limits. The Teichert Project report presents the required mining and reclamation plan, and describes the dewatering operations that will be necessary to conduct the proposed dry-pit mining techniques. Clarifications to the report were prepared and submitted by LSCE in September 1997.

Both the Hoffman and CCCC properties are zoned agricultural and are presently utilized for grazing purposes. The mining and reclamation plan provided in the report describes the mining activity proposed for cropland and irrigated pastureland.

When reclamation activities at the mining areas are completed, land use will include agriculture, lakes, open space and wildlife habitat areas.

As part of Teichert's planning necessary for aggregate production and the reclamation of mined land, LSCE investigated groundwater resource conditions and evaluated groundwater impacts of the proposed mining and reclamation activities. Since dewatering of candidate aggregate deposits will be necessary to conduct the proposed dry-pit mining methods, significant aquifer evaluation studies were performed to document hydrogeologic conditions and prepare monitoring and mitigation alternatives. The issues of concern to water supply wells in the Lincoln GMP area include the long-term lowering of water levels in Lincoln-area wells, and a reduction in potential recharge to the Mehrten aquifer in the Lincoln GMP area. Additionally, impacts to groundwater quality as a direct result of mine-reclamation activities were analyzed by LSCE and compared with baseline conditions. Impacts were reportedly caused by increases in salt and nitrate loads to mine-derived ponds. The mechanism for possible groundwater contamination was not entirely described in the report.

A review of the Teichert Project report indicates that no specific impact assessments were performed for the City's municipal wells. The report states that during the reclamation phase of the project, the maximum predicted additional drawdown in an existing offsite well is less than one foot. The report indicates that this amount of additional drawdown would be indistinguishable from normal seasonal fluctuations in wells. The groundwater level simulations performed by LSCE indicate that no water level declines are predicted in the City wells. Specifically, no impacts are indicated in these wells during either the mining or the reclamation process.

Although Coon Creek does not pass through the Lincoln SOI, this surface watercourse is hydraulically upgradient of the Lincoln area aquifers. The Teichert Project report indicates that the hydrology of the Coon Creek watershed does influence the groundwater flow direction in the Lincoln GMP aquifers including the principal unconfined flow system.

The second impact that the Teichert Project may have on the hydrology of Coon Creek is the reduction in base streamflow. This potential reduction has been estimated by LSCE to be a maximum of 1.0 cubic-feet per second (cfs), which is planned to occur during mining of the alluvial pit. Partial mitigation of the streamflow reduction is anticipated by returning the discharged water to Coon Creek at some location downstream of the dewatering point. However, it appears that there will be a net loss of potential recharge water for the GMP area aquifers.

The Teichert Project report also states that groundwater quality may be improved in the mine area due to the conversion of agricultural land to small lakes. The report further states that the risk of contamination resulting from mining operations or pit reclamation was determined to be small. Comparisons of this Teichert Project with similar in-stream aggregate mining projects in Yolo County were included in the LSCE report for the purposes of illustrating that minimal groundwater contamination is anticipated to occur with these mining and reclamation techniques. The LSCE report concludes that the risk of potential contamination to the City's wells is negligible, primarily due to the approximate four-mile distance between the wells and the mining area.

Titan I - A Missile facility

The U.S. Army Corps of Engineers finished construction of a Titan I-A Missile facility approximately 1.6 miles east of Lincoln in 1962. The facility covered approximately 275 acres and included three 160-foot deep missile silos with adjacent propellant and liquid oxygen terminals. The U.S. Air Force used the site from 1962 until 1965 when the site was closed. The missiles were deactivated, disassembled and removed from the site (FA/BC, 2001a).

Sampling at the Titan Missile facility indicates that trichloroethlylene (TCE) concentrations in groundwater range as high as 920 ug/L. The MCL for TCE is 5 ug/L. Other contaminants found at the site include chloroform, methyl ethyl ketone, m,p-xylene, vinyl chloride, carbon disulfide, petroleum hydrocarbons and acetone and daughter products of PCE including cis-1,2-DCE, trans-1,2-DCE.

The TCE plume is oriented parallel to the general southwestly flow of groundwater according to a report by Forsgren Associates / Brown and Caldwell (2001). A groundwater treatment system is in operation at the site in an effort to remediate the contamination.

Leaking Underground Storage Tanks

Several of the sites have had unauthorized releases from underground storage tanks (UST). Most of these sites are localized in nature and are not indicated to have impacted groundwater.

A limited number of leaking underground storage tank sites have reportedly impacted shallow groundwater with gasoline and diesel fuel products. These locations maintain a number of required groundwater monitoring wells to observe the migration or remediation of the chemicals of concern. Gasoline constituents such as benzene, toluene, xylenes and ethylbenzene (BTEX) and oxygenates such as methyl-tertiary-butyl-ether (MTBE) have the potential to cause degradation of groundwater supplies if not assessed and remediated in a timely manner.

Subsidence

Subsidence is the lowering of the natural land surface due to extraction of groundwater, oil or gas. In areas where the saturated subsurface materials are compressible, withdrawals of groundwater may cause the ground surface to subside. There does not appear to have been any subsidence studies in the Lincoln area.

3

Water Demand and Usage

Demand for water within the City's Sphere of Influence is met through a combination of imported surface water and local groundwater resources. Users include local agriculture, rural residential users, industrial and commercial operations, golf courses and parks, and City residents. Their demands are met directly by the City or through individually owned and operated water systems (i.e. private wells or individual contracts for surface water).

This section provides information regarding local water demands and the water supplies necessary to meet them – providing a context from which to establish basin management objectives (Section 4) and craft management actions (Section 5) for managing local groundwater resources.

Historic and Projected Annual Demand

For this discussion, demands within the City's SOI are separated into two categories:

- Demands served by the City of Lincoln – these include customers who receive treated surface and/or groundwater supplies and are billed directly by the City of Lincoln for their water.
- Demands not served by the City – these include users within the SOI who have contracts directly with PCWA or Nevada Irrigation District (NID) and/or pump groundwater from a privately owned well.

Demands Served by the City of Lincoln

Table 4 presents historical and projected potable water demand for the City of Lincoln forecasted to the year 2025. A rapid increase in demand is expected between the years 2000 and 2015 because of anticipated growth in population, housing, and employment. The largest increase in demand is expected between 2000 and 2005 because of elevated growth rates in housing and employment during that five-year span (SACOG, 2001).

Table 4: Historical and Projected Treated Water Demand (acre-feet)

Year	Treated Water Demand	
1996	2,032	Historical
1997	2,390	Historical
1998	2,169	Historical
1999	2,766	Historical
2000	4,099	Historical
2005	11,440	Projected
2010	16,060	Projected
2015	22,080	Projected
2020	23,150	Projected
2025	23,970	Projected

Water demand projections found in Table 4 are calculated based on housing and employment projections, 2002 commercial and industrial development, and average water use by customer type. Housing and employment projections were taken from the Sacramento Area Council of Governments (SACOG, 2001) in five-year increments from year 2000 to 2025. Land development for commercial and industrial uses for the year 2002 was obtained from the City of Lincoln's Community Development Department. Average annual water usage by various customer types was taken from the Surface Water Supply Update for Western Placer County (PCWA, 2001) for Lower Planning Zone 1, which includes the City of Lincoln.

Projected Residential Water Use

Residential water use is estimated based on the projected number of housing units provided from SACOG (2001). The total number of housing units provided by SACOG is divided into three residential categories: low-density units, medium-density units, and high-density units. Table 5 shows the distribution used to calculate the number of housing units within each category.

Table 5: Distribution of Housing Units by Type

Low-Density Residential	70 Percent
Medium-Density Residential	20 Percent
High-Density Residential	10 Percent

The annual residential water use is calculated by multiplying the number of housing units for each residential category by the average water use. Table 6 shows the daily average water use in gallons per day (GPD) by residential category applied in the projections (PCWA 2001).

Table 6: Average Water Use by Housing Type

Housing Unit Type	GPD/Unit
Low-Density Residential	806
Medium-Density Residential	536
High-Density Residential	188

Projected Commercial, Industrial, and Other Major Water Uses

An estimate of the total acreage of commercial and industrial land developed as of 2002 was obtained from the City of Lincoln's Community Development Department. Estimates of future water use were projected from the 2002 data using the annual employment growth rate provided by SACOG (2001). The projected acreage was multiplied by the average daily water use determined by PCWA (2001) for commercial and industrial land use. Projections for water use by public schools are taken from SACOG (2001). The projected number of schools was multiplied by the average daily water use determined by PCWA (2001).

Table 7 displays the projected water use by customer type to the year 2025. SACOG (2001) projections assume that the City of Lincoln will not annex any land outside the SOI over the next 25 years. The projections predict the annual housing growth rate will level off in 2015 to about 1% due to buildout of land designated for residential development. Consequently, the total residential water use levels off around the year 2015.

Table 7: Projected Treated Water Use by Customer Type (acre-feet/year)

Customer Type	Year				
	2005	**2010**	**2015**	**2020**	**2025**
Low-Density Residential	7,180	10,160	13,900	14,360	14,670
Medium-Density Residential	1,360	1,930	2,640	2,730	2,790
High-Density Residential	240	340	460	480	490
Commercial	300	380	550	610	680
Industrial	1,660	2,120	3,050	3,400	3,770
Schools and Public Facilities	700	1,130	1,480	1,570	1,570
Total	**11,440**	**16,060**	**22,080**	**23,150**	**23,970**

In addition to the direct users of treated water, the golf course at Del Webb's Sun City has the ability to purchase treated water from the City if their primary source of raw water – obtained through an independent contract with PCWA – is unable to meet their needs. This is for emergency purposes only, since the cost of treated water is much greater than that of raw water. This potential demand is not reflected in Table 6.

Demands Not Served by the City

Several demands for water within the City of Lincoln SOI are met through private supplies or individual contracts with PCWA or Nevada Irrigation District (NID). These include local irrigated agriculture, rural residences as well as additional commercial and industrial facilities.

Agricultural Water Use

Historically, agriculture in the Lincoln SOI has been either dry-farmed or irrigated with raw surface water provided by PCWA and NID, or with groundwater from private wells. As shown in Figure 18, approximately 4,200 acres of land within the SOI were farmed at one time during the last three decades[4]. Though much of this was not irrigated, there were approximately 2,300 acres that exclusively used groundwater or relied on groundwater when surface supplies were unavailable. As a result of development with the SOI, the majority of these lands are no longer used for agriculture. Based on the best available data, only about 1,400 acres of irrigated land still remain within the SOI – all of which rely predominantly on surface water.

[4] Estimates of historic agricultural land were based on discussions with local interests and review of aerial photos.

Saracino Kirby Snow

Historic and Current Irrigated Agricultural Lands

City of Lincoln - Groundwater Management Plan

Figure 18

Date: October 2003

Prepared By: BCW

For the near future, it can be reasonably assumed that crop patterns and irrigation requirements will remain similar to current conditions. Since no appreciable quantity of new lands are anticipated to be brought into production, it is likely that agricultural water demand will continue to decrease as municipal/industrial development encroaches on agricultural lands not set aside as open space.

Table 8 provides a comparison of groundwater use by agriculture for historic versus current conditions.

Table 8: Historical Agricultural Water Use[1] (acre-feet/year)

Water Source	Historical (Approx. 1970)	Current
Surface Water	14,670	3,490
Groundwater	3,070	610
Total	17,740	4,100

1. Values were estimated using water use rates of 6.2 acre-feet/acre for rice and 2 acre-feet per acre for irrigated pasture – applied to the acreage shown in Figure 18.

Rural Residential Demand

In the Lincoln SOI there are several rural residences that use private wells for water supplies. For purposes of this plan, there is assumed to be no change in the number of rural residences or their groundwater use within the Lincoln SOI. Data regarding the number of rural residential users with private wells was not available from the City.

Commercial and Industrial Demand

Data regarding the demand for water from several commercial and industrial operations with the SOI is unavailable. Many use private wells to serve their operational needs, including:

- The new Thunder Valley Indian casino – the facility uses groundwater for all of its indoor and outdoor needs and relies on stored groundwater for fire suppression. Discussions have been initiated with the City that may result in the casino transitioning to City supplied water in the near future.

- Pacific Lumber – ponds on the property are used for dust suppression and to maintain sufficient moisture in the cut logs, among other things. Though the City serves this facility, the majority of use is raw water from the ponds. The origin of this water is undetermined, but is likely groundwater.

- Gladding-McBean – this operation has a private well, but the extent of its use is unknown. City supplies are used for potable needs, but are likely not used for operations around the plant.

Other industries including those near the casino also use private wells for their operations. The City intends to transition many of these customers to City supplies during the next 2 years.

Projected Raw Water Use

PCWA currently supplies private customers within the City of Lincoln with 5,600 acre-feet of raw water per year. Agriculture, golf courses, parks, and others use this water supply. PCWA (2001) assumes that deliveries of raw water to these private customers will remain at 5,600 acre-feet per year through buildout. This analysis relies upon that assumption.

Data regarding quantities of raw water supplies from NID to private customers was unavailable. However most NID water within the SOI is used to meet irrigation demands. Figure 2 shows the NID service area.

Historic and Projected Sources of Supply

The City of Lincoln utilizes surface water and groundwater to meet its water supply needs. The City receives its treated water supply from surface water deliveries by PCWA and from groundwater pumped from City-owned wells. Table 9 presents the historical water use for the City of Lincoln in acre-feet for the years 1996 through 2000 (Lincoln, 1995-2000). Data on the amount of surface water delivered to the City of Lincoln was supplied by PCWA. The City of Lincoln supplied its own data on annual groundwater production.

A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate." California Water Code

Table 9: Historical Water Use (acre-feet)

Year	1996	1997	1998	1999	2000
Groundwater	516	484	433	470	569
Surface Water	1,516	1,906	1,735	2,296	3,530
Total	2,032	2,390	2,169	2,766	4,099

Distribution System

Lincoln provides its customers with potable water through a pressurized distribution system. The system consists of one pressure zone, supplied with treated surface water purchased from PCWA and four groundwater wells and operates in the range of 15 – 130 pounds per square inch of pressure. Three gravity storage tanks (1.5, 3 and 5 million gallons) and one 1.5 million gallon pumped storage tank are also incorporated into the system.

Surface Water

Untreated Surface Water

Most of Lincoln is located in the PCWA Zone 1 service area as shown on Figure 2. PCWA obtains water for Zone 1 from either PG&E's Wise/South Canal or PCWA's Boardman Canal. Sources for this water are the Bear and Yuba Rivers. Water from the American River may also be utilized to service Zone 1 (Brown and Caldwell, 2000). Raw surface water is transported to the PCWA Sunset and Foothill Treatment Plants and thence conveyed to Lincoln. PCWA also delivers untreated surface water via PCWA's Capertown Canal system to raw water customers within the City's SOI as described previously in this section. Although portions of Lincoln's SOI are located within PCWA Zone 5, the City receives no surface water deliveries from Zone 5.

The Nevada Irrigation District (NID) delivers untreated surface water via NID's Hemphill Canal to raw water customers within the City of Lincoln.

Treated Surface Water

The City of Lincoln purchases treated surface water from the Sunset and Foothill Treatment Plants through a long-term contract with the PCWA to meet the City's maximum day demands. The City distributes the water to Lincoln businesses and residents through the City's distribution system.

Because the City relies on another party, it is vulnerable to periodic outages, drought induced shortages or other factors out of its control that can affect the availability of treated surface water for the City's customers. This is the primary reason for the City's plans for further expanding the ability to pump groundwater. For instance, within the last several years, PCWA has asked the City to reduce their request for surface water or have, in at least one instance, told the City no water was available[5].

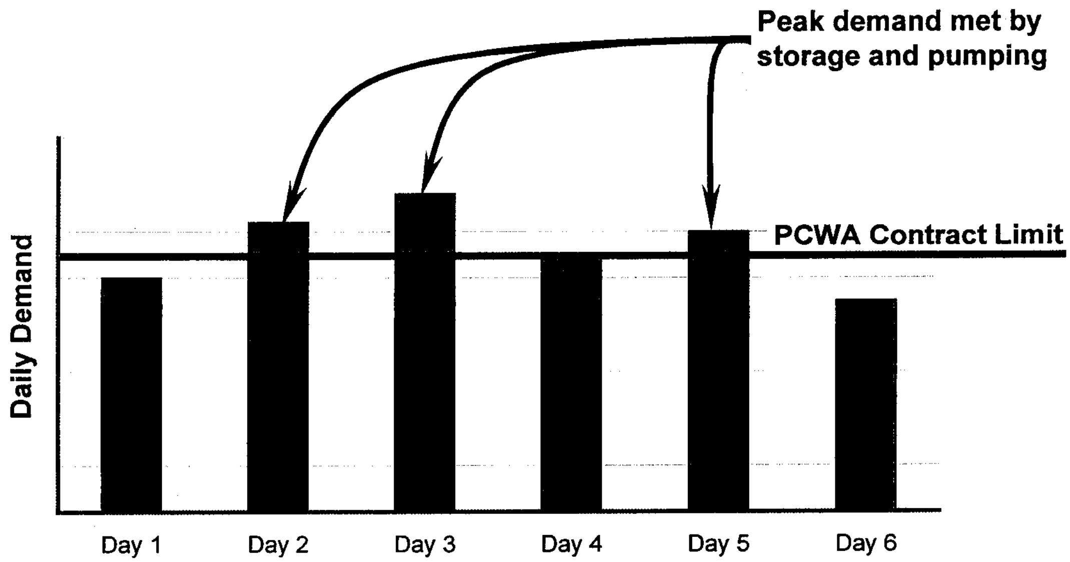

Figure 19: Conceptual Representation of Daily Peak Demand not met by PCWA Supplies

Although the surface water supplies made available by PCWA appear to be sufficient to meet the City's needs – when viewed on a monthly or annual time step – the potential for outages or shortages on a given day compels the City to have backup and emergency supplies available. In addition to periodic outages and shortages, the contract between the City and PCWA limits the daily delivery rate such that the City often experiences peak day demands that exceed the moving contractual PCWA delivery rate. This concept is illustrated in Figure 19.

There are also periodic reductions in surface water deliveries. Deliveries are reduced during maintenance of raw water canals and ditches, which supply raw water to Sunset and Foothill treatment plants. The reduced raw water availability to the PCWA plants combined with unseasonably warm weather is the main reasons for the October 2003 reduction in surface water delivery from PCWA.

[5] PCWA experienced facility problems and was unable to delivery water to Lincoln for several days. The storage tanks, existing wells, and water conservation measures allowed the City to maintain supplies during this critical outage.

Groundwater

The City currently utilizes groundwater from four wells as a source for its water supply. Two wells went offline in summer of 2003 for installation of upgraded equipment, but are expected to be available by summer 2004. Liquid chlorine (sodium hypochlorite) is added to the pumped groundwater at the well site as a preventative disinfectant. All well sites have 10,000-gallon pressure tanks.

The City has plans to increase the number of municipal water supply wells in order to provide necessary backup and emergency supplies and to ensure daily peak demands are met as growth continues. As discussed in the City's 2002 Urban Water Management Plan, the goal is to be able to meet a 20 million gallon per day (MGD) demand with groundwater on a short-term basis by the time the City reaches its buildout population in 2020. This volume is equivalent to 75 percent of the average expected daily demand under buildout conditions – or about 62 acre-feet per day. If there is an extend outage, the well system would need to supply this demand for the entire period of the outage.

The City is continuing with groundwater investigations. The results of these investigations will be analyzed and used to help determine the viability of the City's production goal, optimal well spacing and potential pumping schedules.

Geologic logging, downhole geophysical logging, and aquifer stress tests were conducted in the summer of 2003 as the City pursues two new wells to ensure backup, emergency and peaking supplies are available. Two new wells are scheduled to be drilled near the City's Wastewater Treatment and Reclamation Facility and are expected to be available by summer 2004.

Future Well Locations

The optimum number, locations, spacing, depths, and completion design for planned City drinking water wells will be determined based on the results of groundwater investigations and the actual demand for backup, emergency and peaking supplies. Spectrum-Gasch (1999) estimated that 30% of the area within the current Lincoln SOI is underlain by productive aquifers, which are generally west of Highway 65. Primarily based on the inferred thickness of the productive aquifer zone and existing well information, they identified two areas as having the best potential for high yield wells:

1. Lincoln Airport vicinity

2. Vicinity of Orchard Creek and Ingram Slough confluence

These are preliminary potential future well locations that will be refined based on groundwater investigations.

Sufficiency of Groundwater to Meet Projected Pumping

Existing information indicates that there are significant groundwater resources underlying the Lincoln SOI, especially in the western part of the area A recent study that specifically focused on assessing the groundwater resources across the Lincoln SOI (Spectrum-Gasch, 1999) provided a conservative estimate of 47,250 acre-feet of recoverable water in place, whereas a groundwater modeling study of the larger Northern American River Service Area indicates total groundwater storage of about 287,800 acre-feet (Montgomery Watson, 1995) within the SOI. These estimates are approximately equivalent when the conservative Spectrum-Gasch assumptions are applied. The same modeling study indicates an average yearly total recharge to the Lincoln SOI area of approximately 16,878 acre-feet/year, of which 12,302 acre-feet/year occurs as deep percolation and 1,952 acre-feet/year as inflow from streams, 1659 acre-feet/year boundary inflow and 965 acre-feet/year from other sources. These recharge estimates likely contain a lot of uncertainty and could be significantly improved with refinement and recalibration of the IGSM model over Lincoln Area, incorporating recent and future information on the hydrogeology and land usage. See additional discussion in Section 2.

Implementation Timeline

Several coordinated groundwater investigations are currently underway. One investigation to be conducted by Gasch & Associates involves extending the geophysical surveys to an area north of Lincoln to better characterize the dimensions of the aquifer. Another investigation as Phase II of the Saracino-Kirby-Snow work involves the tasks outlined below:

1. Data collection
2. Design monitoring network
3. Develop a groundwater protection program
4. Research and properly destroy abandoned wells

Results of the investigations will be utilized to determine the number, location and operation of future wells. The City estimates the geophysical investigation will be complete in 2004 with construction of new wells to follow as funding is approved by the City Council.

Expected Increase in Water Supply

Additional groundwater wells will result in an increase level of backup, emergency supply, and peaking protection for the City. The goal is to develop a well field that will be able to meet 2020 supply goal of 20 MGD on a short-term basis. Results from the groundwater studies will provide an estimate of aquifer yield under different pumping scenarios and help the City refine its goal accordingly.

Surface Water and Groundwater Conjunctive Use Program

Conjunctive use is the planned, coordinated use of groundwater and surface water to optimize available water supplies. Surface water is used when it is available and groundwater is used when surface water supplies are reduced or not available. The aquifer is utilized as a storage reservoir that can be recharged from precipitation, subsurface inflow, applied surface water or injection wells. This stored water is then available when needed.

Program Development

A surface water and groundwater conjunctive use program is being developed to more fully utilize the groundwater basin within the Lincoln Sphere of Influence. Surface water will be utilized to meet the majority of the City's water demands and provide recharge to the aquifer. As previously discussed, the well system, in conjunction with water stored in above-ground tanks, provide backup and emergency supplies and help meet peaking demands.

Implementation Timeline

The conjunctive use program will be implemented in phases as the wells are completed. More complete utilization of the groundwater basin will be possible as additional wells are built and operated. Full implementation of the conjunctive use program is expected by 2020.

Recycled Water

Wastewater effluent from the Lincoln Wastewater Treatment Plant (WWTP) is utilized for irrigation at the following four sites with a net area of 382 acres (Eco:Logic, 2001):

- 122 acres near the City airport
- 38 acres at the WWTP site
- 105 acres Antonio Mountain Ranch
- 117 acres Warm Springs site

Plans to increase the use of recycled water are being developed (Eco:Logic, 2001) and could be implemented soon after the completion of the new Wastewater Treatment and Reclamation Facility in 2004.

Data Management

As illustrated with the previous discussion, data relevant to supplies and demands are extremely important to allow the City to manage its available water resources. Also apparent is that data regarding many of the local demands and supply conditions – historic and current –are lacking. To address these issues, the City is preparing a new data management tool. Further details are provided in Section 5.

4

MANAGEMENT OBJECTIVES AND COMPONENTS

Basin Management Objectives

The City of Lincoln's primary groundwater management goal is to ensure a viable resource for use by the City to meet backup, emergency and peak demands without adversely affecting adjacent areas. To measure whether this goal is being met, the City has developed specific objectives – referred to as Basin Management Objectives (BMOs) – that will help guide the City's groundwater management activities. In addition, the City recognizes the value of directing specific management activities toward the twelve groundwater management plan components briefly mentioned in Section 1.

Targeting management actions to specific objectives and components helps ensure that the City is appropriately directing its efforts toward meeting and maintaining its stated goal.

The BMO approach can be divided into seven parts:

- Management Area
- Objectives
- Public Input
- Monitoring
- Data Evaluation
- Adaptive Management
- Compliance

Management Area

For the City of Lincoln, the management area is defined as the City's Sphere of Influence. The City embraces the principle that management actions taken by the City should not adversely impact objectives in adjacent areas.

Objectives

Basin management objectives described herein will be refined to describe acceptable groundwater level fluctuations and the acceptable range of groundwater quality change. Basin Management Objectives (BMOs) can be considered a set of trigger points where management action will be taken if the BMO levels are exceeded. The BMO levels will be reevaluated and reestablished on a regular basis to respond to changes in the basin.

For the City of Lincoln, three general BMOs have been developed and are discussed below.

Data Evaluation

Following data collection there needs to be a process to analyze the data and report any findings or recommendations to the management authority who can then make sound adaptive management decisions based on the results.

Adaptive Management

The City has begun with a general set of BMOs – because existing data and the regional understanding of the basin is insufficient for establishment of more specific objectives. Each year, as data is collected and analysis performed, the City will adaptively refine their BMOs to provide detailed triggers and to establish appropriate management actions. The City intends to continue using the Advisory Committee and interested members of the public to assist with this refinement.

Compliance

The following actions within the City's SOI may be undertaken by the City where BMOs are not being met. These include:

1. Reschedule City groundwater extractions

2. Redistribute City groundwater extractions

3. Redefine the City's management objectives

4. Terminate groundwater extractions

5. Other

For the City of Lincoln, conformity to the BMOs will be the full responsibility of the City. The City will enforce appropriate actions on its own pumping.

Basin Management Objectives for the City of Lincoln

The City of Lincoln will utilize its underlying groundwater for beneficial purposes through implementation of a conjunctive use program. The City of Lincoln's Basin Management Objectives for groundwater levels, groundwater quality and subsurface flow gradient direction were developed for the City's Sphere of Influence (SOI). The BMOs described below have been developed through a collaborative effort involving City staff, the Advisory Committee and interested public participants.

Groundwater Level Objective

The City's first Basin Management Objective is to maintain groundwater elevations at a level that will ensure an adequate groundwater supply for backup, emergency, and peak demands, without adversely impacting adjacent areas. Groundwater elevations underlying the City have remained fairly constant over the past several decades. Measurements taken at numerous wells by DWR over the last 30 years and studies undertaken by DWR indicate that the groundwater basin underlying the City of Lincoln is stable (see Chapter 2). Seasonal fluctuations and the gradual rise and fall in accordance with hydrological conditions are representative of typical conditions in the North American Subbasin.

The City developed this BMO and associated management actions in order to not adversely impact groundwater levels throughout the development and implementation of the conjunctive use program. The City's initial focus, therefore, is to improve the regional understanding of the North American Subbasin by collecting and analyzing hydrological data from the basin. As additional data from the basin becomes available, this BMO may be modified and appropriate management actions will be formulated.

Groundwater Quality Objective

The City's second Basin Management Objective is to preserve overall groundwater quality by stabilizing existing groundwater contaminant migration, avoiding known contaminated areas, and protecting recharge areas. There are 39 known or potential contaminant locations within the City of Lincoln's SOI. These locations include a Missile Base, three landfills, two airports, and other commercial and industrial sites. This BMO indicates the desire of the City to avoid interaction with any of these areas in development and implementation of the conjunctive management program.

In addition, a saline marine layer, the Ione Formation, underlies the primary production zones in the City's SOI. By establishing monitoring programs and appropriate management actions, the City can operate to reduce the risk of introducing or exacerbating saline water intrusion.

As with the groundwater level BMO, however, the present data are insufficient to allow the City to understand all of the water quality characteristics in the City's SOI. Accordingly, the initial intent of this BMO is to develop a better understanding of groundwater quality in the City's SOI and how changes in water quality may be influenced by groundwater management practices and implementation of the City's conjunctive use program. As additional data from the monitoring program becomes available, the Groundwater Quality Objective can be more clearly defined and trigger points established. Ultimately, management actions would include regular collection and analysis of groundwater quality data, comparing it to defined triggers and taking appropriate actions. By meeting this objective the City will not adversely impact overall groundwater quality and will not increase migration of existing groundwater contamination, both naturally occurring and anthropogenic.

Groundwater Gradient Objective

The City's third Basin Management Objective is to ensure that the direction of groundwater flow continues its southwesterly flow pattern despite additional groundwater extractions or other potential influences. Maintaining this directional flow will help ensure that the City's conjunctive use activities do not adversely affect adjacent areas – especially those areas to the west of the City's SOI. Meeting this groundwater gradient objective will contribute to a more reliable water supply.

Planned management actions to meet this objective include analysis of groundwater elevation data and contour mapping. The City will reduce pumping and/or alter pumping regimes to maintain the management objective.

Public Input

Public input to the process is a critical factor for the successful implementation of groundwater management strategies. It is important to accommodate, to the degree possible, the needs and wishes of the local groundwater users in the area being managed.

The City of Lincoln assembled an Advisory Committee comprised of the following

- Lincoln City Council
- City of Lincoln General Manager
- Lincoln Public Works Department
- Lincoln Planning Department
- Placer County Water Agency
- Placer County Board of Supervisors
- Placer County Planning Department
- Nevada Irrigation District
- Regional Water Authority
- Lincoln Chamber of Commerce
- Rural Landowners
- Building Industry
- Gladding McBean Quarry
- Placer County Agricultural Commissioner
- Ranching/farming representative

The Advisory Committee met twice to review and provide input to the draft Groundwater Management Plan. Two additional meetings of the Advisory Committee were held where input from the public was sought. These meetings were announced in the local newspaper, on the City's web page, through the City's eBulletin email broadcast and in the Placer County Farm Bureau newsletter.

Summaries of these efforts are presented in Appendix E and Appendix F.

Monitoring

The City will monitor groundwater levels, groundwater quality, and directional groundwater flow as part of its adaptive management strategy in implementing the conjunctive use program while achieving the BMOs. This will require monitoring groundwater and dissemination of relevant data. In areas where no wells exist or the existing coverage is poor, new monitoring wells may be installed. Participation by individual landowners will be strictly voluntary.

Adaptive Management Strategy

BMO's are subject to an Adaptive Management Strategy. An adaptive management strategy means that each objective may be refined as new information affecting that objective becomes available. For example, future information may become available indicating that certain water management efforts could be undertaken to improve groundwater quality. In this case, the City may modify its basin management objectives to state its intention to "improve" overall groundwater quality as opposed to merely preserving existing groundwater quality. Accordingly, the City will revisit the BMO's each year as more data becomes available on the conditions of the underlying groundwater basin. Similarly, the Management Actions (discussed in chapter 5) will be reevaluated on a regular basis to respond to changes in the BMO's.

AB 3030 Plan Components

The City's BMOs are supported by the AB 3030 Plan Components listed in Section 10753.7 of the California Water Code. The specific actions listed in this section will be used in conjunction with the management actions outlined in Chapter 5. The components are described here to provide context for the City's management actions.

Control of Saline Water Intrusion

The Ione Formation underlies most of the Lincoln management area. As the depth of the Ione Formation increases, it has been recognized that water quality in the formation becomes poor, or more saline. The Ione Formation has not been used extensively for groundwater production due to its generally low water yield and mostly poor water quality.

Wells pumping fresh water from aquifers that are underlain by saline water can cause the saline water to be drawn into the well, a phenomenon known as upconing (Todd, 1980). Upconing is a function of the depth of the saline water below the pumping well's bore hole or lowest screens, the pressure reduction caused by the pumping well, and the volume and duration of pumping.

Significant increases in total dissolved solids (TDS), sodium and chloride could be an indication of upconing of saline groundwater. Results of groundwater quality monitoring in City wells do not indicate these constituents are currently at elevated levels. The City will continue to monitor TDS levels in its existing production wells and, as part of an expanded monitoring program begin monitoring other areas of the basin for signs of potential saline intrusion problems.

Identification and Management of Wellhead Protection and Recharge Areas

Wellhead Protection Areas

The federal Wellhead Protection Program (WHPP) was established in 1986 through amendments to the Safe Drinking Water Act (SDWA). The program was intended to help protect groundwater that supplies drinking water to public water systems. Each state was required to prepare a WHPP and submit it to the Environmental Protection Agency (EPA) by June 19, 1989.

Further amendments to the SDWA in 1996 established the Source Water Assessment Program (SWAP). Central elements of the SWAP – protection area zone delineation, inventory of possible contaminating activities (PCAs), and vulnerability analysis – are also elements of a Wellhead Protection Program.

In California, the source water assessment program is called the Drinking Water Source Assessment and Protection (DWSAP) Program, and satisfies the mandates of both the 1986 and 1996 SDWA amendments. The DWSAP Program provides source water assessments and will facilitate the development of protection programs for both groundwater and surface waters. The DWSAP Program submitted by the California Department of Health Services to the EPA was formally approved on November 5, 1999.

The DWSAPs developed for the City of Lincoln (Saracino – Kirby – Snow, 2002) contains the following elements:

- Location of all Drinking Water Sources
- Delineation of Source Area and Protection Zones
- Drinking Water Physical Barrier Checklist
- Inventory of Possible Contaminating Activities
- Vulnerability Ranking
- Source Assessment Map
- Public Notification
- Report and Summary

Details on each of these elements are included in Appendix G.

Recharge Areas

Recharge of Lincoln area groundwater resources occurs primarily from percolation of irrigation water, infiltration along the creeks and drainages, infiltration of precipitation, and subsurface inflow. Protection of recharge areas is accomplished by controlling or regulating surface contamination before it migrates into the groundwater. Contamination migration can occur either by percolation of surface contamination or through a potential conduit such as a well that has not been properly constructed or abandoned wells that are not properly destroyed. Recharge rates can be maintained by keeping the major recharge areas free of impervious surfaces.

Surface contamination caused by the disposal of waste is regulated by the Central Valley Regional Water Quality Control Board (RWQCB), the Department of Toxic Substances Control (DTSC), and/or the Placer County Environmental Health agencies. These agencies may assist in the identification of areas where contamination is present. These agencies also provide important information regarding environmental management issues and sites of concern that may be located within the Lincoln SOI (presented in Chapter 2).

Regulation of the Migration of Contaminated Groundwater

Groundwater contamination can originate from a variety of sources. The DWSAP program described above in conjunctive with a protection program will help to reduce the likelihood of future groundwater contamination. Existing contamination in groundwater is regulated by a number of State and federal agencies. Effective control and clean-up of contaminated groundwater will require a coordinated effort between the regulatory agencies and the City, though the City has no regulatory authority over contaminated sites

Administration of Well Abandonment and Destruction Practices

State of California regulations require that all unused or inactive wells be properly maintained, in accordance with practices described in California DWR Well Standards Bulletins 74-81 and 74-90. Placer County also has well maintenance requirements. State regulations also require all inactive wells that are not properly maintained (in accordance with Section 24400 of the California Health and Safety Code) be properly destroyed. Wells that are not properly maintained or destroyed can serve as conduits for mixing groundwater of different quality. These potential conduits can allow surface contamination or contaminated shallow groundwater to migrate downward, contaminating deeper groundwater resources.

Replenishment of Groundwater Extracted by Water Producers

The replenishment of groundwater extracted by water producers can be accomplished through active or passive recharge. The City will continue to implement and investigate programs directed at replenishment.

Active recharge consists of intentionally recharging groundwater basins. For example many public agencies are experimenting with groundwater spreading basins and Aquifer Storage and Recovery (ASR) projects in order to supplement the natural recharge rates of a groundwater basin. These management activities may be developed as part of the City's groundwater management plan.

Passive recharge relies on natural processes to recharge the groundwater basin. Although this can be effective in certain types of groundwater basin environments, it is not as successful in achieving the maximum use potential of most groundwater basins.

Monitoring of Groundwater Levels and Storage

Monitoring is a key component of groundwater management. The information needed for an effective monitoring program includes, at a minimum, quarterly groundwater levels, extracted volumes and pumping rates, water quality data, and land use data. The objectives of the Lincoln groundwater monitoring program are to identify areas of recharge, changes in groundwater quality, and changes in groundwater levels. Groundwater level monitoring in supply wells is essential to understand the impacts on the aquifer resulting from changes in surface water supply and groundwater extraction activities. Groundwater quality monitoring is essential to detect degradation of groundwater resources, and to indicate any operational changes needed for the protection of groundwater quality. Ultimately, this data provides the basis from which to measure the success of the City's BMOs and guides the development of trigger mechanism to counteract any identified impacts.

Part of this component will be to develop and maintain a groundwater resource database that is easily maintained and accessible to all potential users. Such a database can help the City identify groundwater quality trends and monitor the impacts of groundwater recharge activities. A description of the City's database efforts is included in Section 5.

Facilitating Conjunctive Use Operations

In the Lincoln area, groundwater and surface water have historically been utilized in a conjunctive manner only incidentally. Surface water infiltration to the basin has not been formally tracked or inventoried. Because of the availability and variability of the surface water supply that occurs in the Lincoln area, there may be opportunity for better utilization of the overall water supply through an expanded conjunctive use program.

Identification of Well Construction Policies

Improperly constructed wells can result in poor well yields and contamination of groundwater by creating unintentional pathways for contaminants. A well construction policy will help reduce the likelihood of poorly constructed wells. Since 2000 the City has been solely responsible for issuing new monitoring well permits for construction or abandonment of wells within the City Limits. The City does not allow additional private wells to be drilled in the City Limits.

Construction and Operation of Projects

Ultimately, the effective management of the groundwater basin will require the planning and construction of projects that assure the quantity of groundwater in storage is sufficient to meet long-term demands. The City may need to make provisions for the thorough study of potential projects, including compliance with the California Environmental Quality Act (CEQA) and the National Environmental Protection Act (NEPA), in addition to their construction and operation. Such projects could include conjunctive use, water recycling, and groundwater cleanup. As discussed in Section 3, the City is nearing completion of a state-of-the-art water recycling plant that will augment local supply conditions.

Maintain Relationships with State, Federal and Local Agencies

The City recognizes the benefit of close coordination between their efforts and the services performed by the various County, State and federal agencies to monitor and protect groundwater resources. The City's goal is to coordinate their management activities with the appropriate agencies, to ensure mutual assistance among those agencies, to minimize duplicated services, and to establish efficient data compilation and exchange procedures. A complete public participation program is described in Section 5.

Review of Land Use Plans to Assess Risk to Groundwater

In California, most land use decisions are made by city and county agencies. Land use activities can affect both groundwater quality and quantity. An important component of the City's GMP will be the review of land use plans and coordinating efforts with regional and local land use planning agencies. City input to these evaluations will aid in making land use decisions to assure protection of the groundwater resource.

5

MANAGEMENT ACTION PLAN

The City has identified three primary Basin Management Objectives (BMOs) that, if met, will help the City accomplish its goal of ensuring a viable groundwater supply that will meet backup, emergency and peak demands without adversely affecting adjacent areas. These BMOs include maintaining groundwater levels, managing to maintain or improve groundwater quality, and maintaining existing regional groundwater flow directions.

AB 3030 Components

1. Control of saline water intrusion
2. Identification and management of wellhead protection areas and recharge areas
3. Regulation of the migration of contaminated groundwater
4. The administration of a well abandonment and well destruction program
5. Mitigation of conditions of overdraft
6. Replenishment of groundwater extracted by water producers
7. Monitoring of groundwater levels, quality and storage
8. Facilitating conjunctive use operations
9. Identification of well construction policies
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects
11. The development and maintenance of relationships with state, federal and local regulatory agencies
12. The review of land use plans and coordination with land use planning agencies to assess activities that create a reasonable risk of groundwater contamination

To achieve these objectives, the City recognizes that a substantial number of management actions must be continued or implemented. In many instances, these actions apply to more than one BMO and relate to multiple AB 3030 management plan components. Table 10 maps these relationships.

Some of the following groundwater management actions have already been undertaken, others are slated for implementation and have a budget, and others are still in the planning stage. The City intends to apply for various grant funds administered by the State in order to seek funding for implementation of desired management actions.

Table 10: Relationship of Management Actions to BMOs and AB3030 Components

Action	Elevation	BMO Quality	Gradient	AB3030 Component
1. Develop and implement a groundwater monitoring program				
a. Expand the network	X	X	X	7
b. Collect relevant well and aquifer data	X	X	X	7
c. Establish data collection methods and frequency	X	X	X	7
d. Develop a groundwater database	X	X	X	7
e. Identify water quality constituents of concern	X	X	X	1,7
f. Monitor fresh water/saline water interface.	X	X	X	1,7
g. Monitor status of known contaminant sites	X	X	X	3,7
h. Annually prepare and present data	X	X	X	7
i. Research and apply for relevant grant funding	X	X	X	7
2. Improve understanding of groundwater basin				
a. Develop and utilize a groundwater model	X			1,2,3,5,6,8
b. Characterize and evaluate local conditions	X			1,2,3,5,6,8
c. Develop a water budget; estimate the perennial yield	X			5,6,8
d. Research and apply for relevant grant funding	X			1,2,3,5,6,8
3. Continue long-term planning and evaluation of potential projects				
a. Explore conjunctive use opportunities	X		X	5,6,8,10
b. Develop a recharge program	X		X	5,6,10
c. Review proposed development plans	X	X	X	2,12
d. Research and apply for relevant grant funding	X	X	X	5,6,10
4. Establish operational requirements for City production wells				
a. Develop spacing and well operation guidelines	X	X	X	1,3,9
b. Establish policies and protocols for BMOs	X	X	X	7,8
5. Develop and implement a Groundwater Protection Program				
a. Conduct a search for abandoned wells		X		1,4
b. Review permits for the destruction of wells		X		1,4
c. Establish standard well construction policies		X		3,9
d. Determine well requirements to minimize saline upconing		X		1,9
e. Map known contaminated sites		X		3
f. Research and apply for relevant grant funding		X		1,3,4,9
6. Continue Public Participation				
a. Make results of monitoring program available	X	X	X	7
b. Continue Advisory Committee	X	X	X	11,12
c. Engage state and federal regulatory agencies				11
d. Continue to engage local agencies and interests				11

City of Lincoln Groundwater Management Plan Actions

1. **Develop and implement a groundwater monitoring program**
   Key to achieving the City's goal is the ability to know the implications of actions taken by the City's and other groundwater users on the basin. Without monitoring, the City and interested stakeholders will not know whether the City is meeting its stated BMOs, nor know if changes is the basin result from the City's activities (pumping and recharge) or from other basin activities. At this time, the City's monitoring consists only of level, production and quality at the City's production wells. The City does not currently obtain elevation or water quality data from other wells in the SOI or adjacent areas.

   A comprehensive monitoring program – directed at groundwater levels and quality – will provide the City with valuable data to make informed decisions regarding the management of the basin. Actions to be undertaken by the City include:

   a. Expand the network of City monitoring wells to include all groundwater bearing areas of the SOI and selected adjoining areas.

   b. Collect relevant data (i.e. DWR driller's logs, downhole electric and geophysical logs, surface locations, well construction details, elevation data, production quantities and water quality).

   c. Establish standardized data collection protocols and the frequency of water level and quality monitoring. Document the protocol for data collection and processing. Provide training for at least two City staff for performing data collection according to these protocols.

   d. Develop a groundwater database with user-friendly interfaces for storage of all data collected.

   e. Identify the primary water quality constituents of concern, which at a minimum would include iron, manganese, arsenic, nitrate, sodium, chloride and total dissolved solids (TDS).

   f. Determine and monitor the elevation of the fresh water/saline water interface. Analyze for trends in sodium, chloride, and TDS that may indicate upconing of saline water.

   g. At known contaminant sites monitor concentration, remediation and migration of groundwater contaminants.

   h. On at least an annual basin, prepare charts, graphs, and maps presenting potentiometric surfaces and groundwater quality data.

2. **Improve understanding of groundwater basin**
   The City has spent hundreds of thousands of dollars over the last decade improving their understanding of the basin. As detailed in Section 2, these activities range from seismic investigation to borehole characterizations. However, the data generated to date is still inadequate to provide the City with the supporting information it needs to manage the basin. Without more data, details, and correlations, the City is unsure of the response of the basin to certain pumping and recharge activities.

   > ***"Additional study of groundwater resources is necessary to better understand how to manage groundwater effectively to ensure the safe production, quality, and proper storage of groundwater in the state." California Water Code***

   The monitoring program detailed under *Management Action 1* will provide valuable temporal and spatial data that can be used to calibrate improved groundwater models and derive correlations between pumping and recharge activities and the basin's response. Actions to be undertaken by the City include:

   a. Develop and utilize a groundwater model to predict potential impacts to drinking water supplies and local groundwater conditions.

   b. Characterize and evaluate groundwater and aquifer conditions in the City's SOI to guide the City's groundwater operations.

   c. In coordination with PCWA, develop a Placer County water budget and estimate the perennial yield of the underlying groundwater basin.

3. **Continue long-term planning and evaluation of potential projects**
   Improved monitoring coupled with improved understanding of the basin's response to particular pumping and recharge conditions is critical to the City's ability to access the identified growth and to explore additional sources of water. Currently, the City's master plan identifies significant growth for the Lincoln area over the next 20 years. To provide for the emergency, backup and peaking demands, the City will continue to explore opportunities for effective conjunctive management. In addition, because recharge to the basin is a key component of conjunctive use, it is critical for the City to provide and maintain adequate recharge capacity as development occurs. Actions to be undertaken by the City include:

   a. Explore conjunctive use opportunities with PCWA, other water purveyors, local ranchers and farmers and neighboring entities

   b. Develop a recharge program that identifies major recharge areas, quantifies current recharge rates, identifies potential sources of surface water that could be utilized for recharge, and methods for recharging groundwater.

c. Review proposed development plans and associated environmental documentation to assess the potential groundwater impacts resulting from proposed land use changes.

4. **Establish operational requirements for City production wells**
The City currently operates its wells to provide backup, emergency and peaking supplies. At current rates, this practice is acceptable and does not seem to have adverse affects on local groundwater conditions. Through improved monitoring, characterization and modeling, the City will have a better understanding of the response of the basin to particular conditions and can, therefore, design operations to ensure compliance with the BMOs. Actions to be undertaken by the City include:

a. Develop spacing and well operation guidelines in order to meet production goals with minimum adverse impacts to the basin and other groundwater users.

b. Using data from the monitoring program, establish policies and protocols to limit extractions to maintain groundwater levels and quality as specified in the City's BMOs.

5. **Develop and implement a Groundwater Protection Program**
The City will develop and implement a groundwater protection program. Actions to be undertaken by the City include:

a. Conduct a search for abandoned wells that may provide a conduit for saline water to enter freshwater subsurface zones.

b. Review permits for the destruction of abandoned or inactive wells.

c. Establish standard well construction policies.

d. Determine the optimal well sites, well depth, depth of well screens, well spacing, and pumping regimes to minimize the potential for upconing of saline groundwater.

e. Map and document, based on monitored data, trends in concentration and movement of groundwater in and around known contaminated sites.

6. **Continue Public Participation**
Public participation and the input of the Advisory Committee were critical to the development of this plan. The City strongly believes in and is embracing the value of open communication among all participants in the basin – whether in relation to the City's activities or that of others who pump groundwater from the basin. Open and honest communications will build trust among basin users, allow the collection and sharing of related data, and allow the basin to be managed optimally for all interested parties. Actions to be undertaken by the City include:

a. Interpret and make results of monitoring program available to stakeholders and other interested members of the public.

b. Hold meetings or workshops of the Advisory Committee on a minimum of a quarterly basis.

c. Continue existing and develop new relationships with state and federal regulatory agencies.

d. Continue to engage local agencies and interests within and adjacent to the Lincoln SOI.

7. **Apply for grant funding to assist with management efforts.**
   The aforementioned management actions are underway or will soon be undertaken by the City as it continues toward its goal of providing viable backup, emergency and peaking water supplies without adverse affects on adjacent areas. The City has budgeted for this coming year to provide funds for these management actions. However, the City will continue to build on past successes of others in the region (i.e. the Regional Water Authority) to obtain state and possibly federal grant funds to augment the City's budget. Through its participation in a successful grant application prepared by RWA on behalf of its members, the City will receive $125,000 for residential irrigation rain sensors, $150,500 for park irrigation upgrades and $90,000 for evapotranspiration irrigation controllers.

Public Participation Program

One indicator of an effective groundwater management plan is plan implementation without substantial challenge. Key to this outcome is that the groundwater management plan reflects the goals and objectives of people who work, live, and have interests in the groundwater basin. As discussed previously in this document and as noted in the meeting notes in Appendix E, the City has implemented a public participation program.

The objectives of the City's program are:

1. To foster strong and effective working relationships between the City of Lincoln, the Placer County Water Agency, and other public entities whose service areas or boundaries overlay the groundwater basin.

2. To provide a mechanism by which stakeholders and interested parties can participate in developing the plan.

3. To support the vital role of groundwater stakeholders in shaping and carrying out a groundwater management plan that addresses their concerns and interests.

4. To recognize the policymakers as the final decision-makers on the groundwater management plan.

5. To include a broad array of voices among the people who live, work, and have interests in the groundwater basin.

6. To create means for the exchange of information among stakeholders.

7. To lead to a broadly supported groundwater management plan.

The recommended framework and typical chronology of a public participation program is detailed in Appendix F. Implementation of the public participation program will require City of Lincoln dedication to meaningful stakeholder involvement and to such resources as meeting space, database management assistance, logistical assistance, and preparation of materials and graphics.

Implementation will also require significant technical and facilitator involvement. The benefits of a successful public participation program include a stronger groundwater management plan and an atmosphere of cooperation on groundwater resource protection issues.

Written Statement to the Public

Several written statements were provided to the public that described the manner in which interested parties could participate in developing the groundwater management plan. These included newspaper articles and news releases, posting notices of the Advisory Committee meetings and a link to a copy of the draft plan on the City of Lincoln official web page, publication in the newsletter of the Placer County Farm Bureau, and publication in the newsletter of the Regional Water Authority. These are provided in Appendix D.

Data Management Tool

To provide a tool to assist with managing data from the monitoring program (see *Management Action* 1d) and thus management of the water resources, the City is constructing a new relational database. The ability to easily store and access data using a relational database relevant to management of local water resources provides many benefits, including: (1) easy access to time-series of data that is invaluable for various analyses; (2) the ability to visualize data when combined with a geographic information system; (3) the ability to easily share data among local responsible parties; and (4) all data relevant to the entity managing the groundwater basin are in one database. Combined, these benefits lead to an improved understanding of the basin and allow for more effective management.

The detailed information contained within the database can be summarized as:

- Well Information – such as location, owner, type, size, depth of screens, enclosure, status, strata seals, casing depth and material
- Production Data – time series of well production records
- Well Driller's Reports – boring depth, gravel pack, lithology, sanitary seal
- Well Test Data – standing water level, drawdown, efficiency, and yield
- Aquifer Parameters – lithology, porosity, hydraulic conductivity
- Water Quality Samples – time series of samples and the tested quantities of numerous constituents
- Contaminant Site Information – location, extent and flow direction of plumes, types of contaminants, extent of contamination, status of remediation, oversight agency

Initially, the database has been populated with information obtained from nearly 200 paper well log records and local contaminated site information[6]. Production data and groundwater elevations have not yet been entered. Such historic data will be entered into the database in the near future and the City will begin to refine its internal protocols to ensure that all data collected into the future is entered into the database.

Using the well log data entered into the database, a subset of well logs with a "high" quality rating has been generated[7]. Seventeen wells comprised the list. Some of these wells could be used to help establish an expanded monitoring network for the City, however data regarding their status, ownership, and other characteristics are not yet available.

[6] Portions of the original paper well log data was converted to electronic form by Gasch and Associates. Contaminated site information was converted by Applied Engineering and Geology.
[7] The quality rating was established by Gasch and Associates and represents their professional opinion regarding the quality and usability of the original paper well log data.

REFERENCES

Anderson Consulting Group. (1999). "Soil and Groundwater Investigation Report to Alpha Explosives."

Boyle Engineering Corporation. (1990). "Airport Vicinity Groundwater Investigation, City of Lincoln, Draft Summary Report."

Brown and Caldwell. (2000). "Placer County Water Agency Urban Water Management Plan."

California Department of Water Resources. (DWR). (1974). Bulletin 118 – 3 "Evaluation of Groundwater Resources in Sacramento County."

California Department of Water Resources. (DWR). (1978). Bulletin 118 – 6 "Evaluation of Groundwater Resources: Sacramento Valley."

California Department of Water Resources. (DWR). (1991). Bulletin 74 – 90 "California Well Standards."

California Department of Water Resources. (DWR). (1992). "Model Landscape Ordinance."

California Department of Water Resources. (DWR). (1995). "Pre-Feasibility Report: American Basin Conjunctive Use Project."

California Department of Water Resources. (DWR). (2002a). Bulletin 118 – 2002 "Groundwater Basins in California." DWR web site http://www.waterplan.water.ca.gov/groundwater/

California Department of Water Resources. (2002). Water Level web site http://wdl.water.ca.gov/gw/

California Water Code. (2002). Groundwater Management Act.

City of Lincoln. (1999). Annual Report to the Drinking Water Program for Medium and Large Water Suppliers.

City of Lincoln. (2003). Water quality data.

ECO: LOGIC. (2001). "City of Lincoln Wastewater Reclamation Study, Administrative Draft."

Forsgren Associates / Brown and Caldwell. (2001). "2001 Annual Groundwater Report, Titan I-A Missile Facility.

Forsgren Associates / Brown and Caldwell. (FA/BC). (2001a). "Community Relations Plan Titan I-A Missile Facility Lincoln, California."

Freeze, Allan R. and John A. Cherry. (1979). "Groundwater."

Groundwater Resources Association of California. (1997). "California Groundwater Management."

Hydrometrics, Inc. (2002). "April 2002 Groundwater Monitoring Report for Alpha Explosives Lincoln, California."

Hydrometrics, Inc. (2001). "Groundwater Characterization and Capture Analysis Report for Alpha Explosives Manufacturing Facility Lincoln, California."

Luhdorff and Scalmanini. (LSCE). (1997). "Final Report and Addendum to: Groundwater Conditions and Projected Mining Impacts, Teichert Aggregate Facility Placer County Project."

Montgomery Watson. (MW). (1995). "Northern American River Service Area Groundwater Model, Model Development and Basin Groundwater Management, Final Report."

Montgomery Watson. (MW). (1996). "Northridge Water District Conjunctive Use Study."

Placer County Planning Department. (2003). Web Site. http://www.placer.ca.gov/planning/planning.htm

Placer County Water Agency. (PCWA). (2001). "Surface Water Supply Update for Western Placer County."

Placer County Water Agency. (PCWA). (1999). "Groundwater Stabilization Project, Final Environmental Impact Report."

Placer County Water Agency. (PCWA). (1998). "West Placer Groundwater Management Plan."

Sacramento Area Council of Governments. (1988). "Lincoln General Plan."

Sacramento Area Council of Governments. (2001). "Population Projections."

Saracino-Kirby-Snow. (2002). "City of Lincoln Drinking Water Source Assessment"

Spectrum-Gasch Geophysics. (1999). "Geological and Geophysical Investigation of the Groundwater Resource City of Lincoln, Sphere of Influence."

Todd, D.K. (1980). "Groundwater Hydrology."

U.S. Bureau of Reclamation. (1994). "American River Water Resources Investigation."

U.S. Census Bureau. (2000). Census.

Western Regional Climate Center. (WRCC). (2003). "Period of Record Climate Summary." web site http://www.wrcc.dri.edu

APPENDICES

A	Resolution to Prepare a Groundwater Management Plan
B	Groundwater Quality Data
C	Resolution Adopting the Groundwater Management Plan
D	Documentation of Notice to Public
E	Advisory Committee Agendas and Minutes
F	Public Participation Program
G	Drinking Water Source Assessment Elements